# The Foundry Trade Journal

AND PATTERN MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 18. APRIL, 1916. No. 172.

PUBLISHED THE FIRST WEEK IN EACH MONTH.

Subscription Terms: 7s. 6d. per annum, post free.

To place the "Journal" within the reach of working Moulders and Pattern-makers, the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5s. per annum, such order to be countersigned by the superintendent or foreman.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

The Foundry Trade Journal,
165, Strand, London, W.C.

OWING TO THE REDUCTIONS IMPOSED BY THE GOVERNMENT ON PAPER SUPPLIES, THE PROPRIETORS ARE COMPELLED TO PUBLISH "THE FOUNDRY TRADE JOURNAL" ON A THIN PAPER DURING THE CONTENUANCE OF THE RESTRICTIONS.



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## Forthcoming Events.

APRIL 14.

*British Foundrymen's Association: London Branch.*—Address by Mr. W. Mayer (President of Association).

*British Foundrymen's Association: Birmingham Branch.*—"Some Characteristics of Iron: Their Transmission to the Castings," by R. Buchanan, F.R.S.A.

APRIL 29.

*British Foundrymen's Association: Newcastle-on-Tyne Branch.*—"The Prehistoric Founder," by B. W. Johnston.

MAY 5.

*British Foundrymen's Association: Lancashire Branch.*—Annual Meeting and Election of Officers; discussion on foundry problems.

## NOTES AND COMMENTS.

### Theories and Their Value.

Practical workers are notoriously indifferent to the academic disputes which theorists wage with each other, and perhaps it is well they should be so. Any attempt on the part of the practical man to follow the complex sinuations of the academic mind, particularly on such subjects as metallurgy, are so apt to obscure the real essentials which are involved in the daily work that it is usually safer to wait until the dispute has subsided and then seize on such clear pronouncement as can be offered by the combatants mutually. When any such pronouncement is finally made, the practical man's first business, before accepting it, is to enquire whether or not it fits in with the experience of works practice. It will then frequently be found that it only does so under certain combinations of conditions. It is an inevitable failing of research and theoretical work that only one set of conditions and one section of a problem can well be dealt with at a time; and this in itself would not be such a failing were there less inclination to hastily publish the results and dogmatises thereon. The more logical and advanced research worker certainly is far less to be charged with this haste than those who have had less experience of the instability and disintegration of theories. To dogmatise is perhaps a tendency common to the human race; but when the basis is experimental work in metallurgy, particularly conducted on other than a practical and commercial scale, it is dangerous. There are many abstruse problems which, while intimately affecting the industrial side, can only be solved in the laboratory; and the past fifty years have seen a wealth of knowledge unearthed by the untiring efforts of the scientist working in obscurity and for sheer love of research. But the results of much of this work are still far from complete, and the tentative conclusions that have been proffered thereon are frequently repeated by others as finally established fact, ignoring the conditions and limitations which the original worker may have acknowledged to influence the case.

In all technical work the establishment of a constant is highly desirable, for the more factors that can be proved constant the less are the variables. But it is a prime essential that the constancy be actually proved; or if it cannot be absolutely proved, that its limitations and conditions of variation be recognised. The failure to do this is at the root of the trouble in standardising the use of irons in founding. Research has afforded, for example, extremely valuable information on the influence of varying proportions of silicon in cast iron under certain conditions. When approximately those conditions persist the facts established form a constant which can be safely relied upon in practical working. But when the conditions are changed, as by the introduction of an element which is not amenable to the influence of silicon to the same extent, or when some external condition is considerably modified, the constant ceases to exist as such. To state a concrete case, the influence of silicon on iron produced under particular blast-furnace conditions is

always the same, and so long as the conditions of iron-smelting are not seriously altered the founder is not likely to be mislead. But when iron produced under different conditions is being handled, or when there are present other unrecorded elements, even in very small proportions, the same results cannot be got. So far as other than the usually ascertained elements are concerned, we cannot too heartily endorse Professor Turner's remarks (reproduced on another page) to the effect that many phenomena might be explained by a more comprehensive analysis of the material. As he stated, ordinary analysis may determine the amount of carbon, silicon, phosphorus, sulphur and manganese; but it does not always determine the nitrogen, copper, nickel, chromium, tungsten, titanium or vanadium. Those elements are sometimes present in small quantities, and produce a great effect. Professor Turner does not think it can be said that certain materials showing great differences have exactly the same chemical composition, and to a great extent that is undoubtedly correct. It is not advisable to look to allotropy for an explanation until most other possible causes have been exhausted. But when an element exhibits distinctly different properties in different irons the fact should be recognised, no matter under what name.

Carbon is a familiar example of a material having allotropic modifications, though most metallurgists are loth to agree that graphitic carbon may be so modified. Be that as it may, the physical properties of graphite are not the same in all irons from the foundryman's standpoint, and the differences persist even after melting. Allotropy strictly may not enter into the case at all; but does it matter really what name is used when differentiating graphitic carbon for practical purposes?

Not very long ago a section of the metallurgical world facetiously conducted, at a meeting of eminent metallurgists, a ceremony which was described as "the burial of Beta"—in other words, they claimed to extinguish for ever the suggestion that there existed that allotropic modification of iron which had been designated Beta iron. To the casual observer of the procedure there was a distinct suggestion that the personal triumph was as much in view as the scientific attainment; but however that may have been, Beta has of late shown rather feline characteristics in developing new life. We now await the renewal of the execution and interment, though it is to be feared it will be interment of name only, since the physical phenomenon which gave rise to the suggestion of allotropy is not to be suppressed by mere argument.

**Pig-Iron and Warrants.**

The Government has recently issued regulations under the Defence of the Realm Act which have summarily stopped all speculative dealings in pig-iron and other metals. The ordinary user of pig-iron will not be disposed to be much distressed by this suppression of speculation, for it has frequently served to send prices soaring upwards when the actual consumption in relation to production did not warrant increases. Legitimate business under such conditions always suffers, and there has been a feeling in the trade for some time that the conditions tending to aid such speculation should be changed. Speculation in pig-iron, of course, does not usually involve the actual delivery and acceptance of the metal, which is actually iron in public stores, but the negotiable warrants which represent the iron. The warrant system originated in a period of serious business depression and helped to tide many pig-iron makers over bad times, by reason of keeping their furnaces operating regularly in the face of an irregular demand. It proved under the conditions of its inception to have considerable value, and would still have that value but for the incidental facility which it affords for pure gambling in an article of commercial necessity. Of course, the warrant system did not apply to all districts and makes, for many classes of iron were quite outside its scope. But as the iron received into the stores was necessarily up to a certain standard, and was the product of the large Cleveland district, it necessarily represented an important section of the trade. Hence the fluctuations in "warrant" prices have generally been more or less reflected in other classes of iron.

While this system of storing iron and realising its value on the exchange of warrants representing it was very helpful at times to pig-iron makers, in avoiding the locking up of their working capital in large stocks at their own yards, the purely speculative or gambling transactions in warrants have in the past had a distinct influence on the markets of those products which depend on pig-iron as a raw material. The recent high prices of pig-iron, however, it must be understood, have not by any means resulted from warrant speculations alone, though the latter have had some influence in Cleveland iron; the chief causes are directly related to war conditions. Our output of iron, practically stationary for years past, is below the pre-war level, and it is somewhat remarkable that the price of Cleveland iron remained so low until quite recently. Nobody seemed to require it, until the great shortage of iron and steel gradually made itself felt. In the meantime, Scotch pig-iron makers' prices have touched figures not realised for 40 years.

As to whether the warrant system will be resumed after the war, it is difficult to forecast; but it is quite possible that the market has seen the last of the storing companies, at least on the old lines. Some two or three years ago, following on the failure of a large Glasgow firm, efforts were made by the Cleveland makers to put a stop to the speculative side of the trade, but without success. The West Cumberland warrant stores and the Scotch iron warrant stores are now only memories, and at the present rate of consumption the stock of Cleveland in store would have been exhausted in a few months and speculation in the warrant market would then have died a natural death. The warrant system is useful more particularly to firms who are financially weak; but in these days of amalgamations the smaller maker is disappearing and the trade tends to gravitate into a few strong hands. In the circumstances the makers prefer the simple operation of the law of supply and demand, and there is some doubt as to whether warrant stores will again be revived.

**The Pig-Iron Merchant.**

Under the new Regulations above mentioned the position of the merchant is somewhat uncertain. The object of the Government is admittedly to stop speculation but not to interfere with legitimate business. As a rule merchants' business is quite outside the speculative movements in question, if the inevitable speculation in any business enterprise be excepted. Under the present rules, however, merchants are in a difficulty, not only in the matter of maximum prices but on account of the fact that the business involves forward buying. The Regulations read that dealing is prohibited "unless in the case of a seller, the metal to be sold is in the possession of the seller or is in the course of production for him; or in the case of a buyer the purchase is made for or on behalf of a consumer." The official explanation further states that "It is permissible for

merchants to replace metals sold after March 1, 1916, by the purchase of an equivalent quantity of the same metal." These regulations may meet certain sections of the trade, but they do not meet all.

The pig-iron merchant cannot stock his iron. He knows that he will sell a certain tonnage in the next quarter, which may be more or less than in the previous quarter, and he should surely be allowed to purchase this quantity at a reasonable rate of profit, unless the Ministry of Munitions intends to shut out the merchants. With fixed maximum prices it would appear that there is no niche for the merchant, and that if he is allowed to deal at all he must become an agent at a prearranged rate of commission. There seems also to be ground for the assumption that some makers are endeavouring to take advantage of the present abnormal conditions to dispense with his services. We do not think that this is likely to meet with the approval of the consumer who has been accustomed to buy through his merchant the various brands of iron that he may require regardless of what number of makers or furnaces is concerned, with quantities, deliveries and payments to suit his requirements. It is probably not practicable, even if it were desirable, to carry on the business without the aid of the merchants. As part of their stock in trade the latter possess an intimate knowledge of the sources of supply, values and natures of different irons, and many consumers make good use of this knowledge. It is by no means uncommon to find the merchant acting as adviser to the founder he is supplying with metal, and were the founder thrown back summarily on to the mercies of the maker, whose concern it is to sell only one or two brands, he would often be in a difficult position. The small consumer, too, would find it almost impossible to deal direct with the maker.

**German Manganese Shortage.**

In our last issue we commented on the question of the German shortage of manganese, and the possible substitutes that were being used. Since then an item has appeared in the German newspapers to the effect that the German substitutes for imported manganese ores are Nassau brown ore, and also Styrian (Austria) manganese ore. If the Siegerland manganiferous ores are left entirely out of consideration, the Germans have a production, it is stated, of 250,000 to 300,000 tons per annum, whereas the imports from the Caucasus and India formerly amounted to about 500,000 tons yearly. The mines in the Siegerland produce about 1,750,000 tons of manganiferous iron ore annually, which has an average manganese content of 12 per cent., and which, it is claimed, fulfils the purpose.

At the annual meeting of the Verein Deutscher Eisenhüttenleute, on March 12, Dr. Petersen, in the course of a Paper on the "War Problems of the Verein," stated that the situation of the iron-ore supply was very favourable. The supply of manganiferous ores had been assured, from which ferro-manganese and spiegeleisen were made. In addition, a substitute for manganese had recently been discovered in so far as it served as a means of deoxidation for basic iron and the steel bath. In the same way they could hold out in regard to other auxiliary materials, such as high-speed steel, ferro-silicon, aluminium, magnesite, etc., so long as the war might last.

While such statements do not necessarily constitute evidence that there is no shortage, it certainly is not safe to assume that the steel output of Germany will be materially restricted by a scarcity of manganese or any other element. When a nation's existence is at stake many expedients become possible which would in normal times be impracticable.

## Value of Scientific Research.

The latest issue of the "Journal of the West of Scotland Iron and Steel Institute" contains some interesting remarks by the President (Mr. Herbert Beard) on the invitation issued to technical societies to co-operate in the Government "Scheme for the Organisation and Development of Scientific and Industrial Research," MR. BEARD said he hoped it was devised, using the words of Henry Poincairé, to ascertain the facts which give a large return. He continued:—

We are constantly questioning the wisdom of some of the authors who fill the pages of institute journals, who should be advised, as the Honourable Robert Boyle was when Sir Isaac Newton wrote to him regarding his experiments on the possibility of the transmutation of metals, "I question not but that the great wisdom of the noble author will sway him to silence till he shall be resolved of what consequences they be." Our metallurgists, micro-mechanicalists, micro-metallographers will not be swayed to silence until they be resolved of the consequences. They must publish even if more than half, or even the whole, of what they say remains in the limbo of "Transactions" and never meets the eye again. An Emeritus Professor of Metallurgy has said, "Current metallographic writings are too often obscured by vague language, not rarely a cover for vague thought." We know perfectly well confusion in the use of terms is very common in the lay mind, and we think it is not less so in the case of the technical mind. We cannot detach our thought from the seriousness of the Government request to organise scientific and industrial research. To do so we must get beyond the stock phrases of research. I remember an address by Mr. William Whitwell, then President of the Iron and Steel Institute, at the International Engineering Congress held in Glasgow in 1901. He spoke of the value of the microscopic method of investigating the structure of steels, how it had become an indispensable auxiliary to chemical analysis and physical tests in steel works. At that time the mass of publications in the matter was very great; he could never have conceived how increasingly voluminous it would become. We had no coloured graphs in the journals of iron and steel institutes. We did not hear of authors being "compelled to believe," or that "one was forced to question whether there is sufficient evidence." We had not heard of "ghost-lines," of "phantom streaks," of "micro-ghost-lines," "horror upon horror's head"! of any of the bogeys used nowadays to frighten the steel-maker, which, it is admitted, may not be as harmful as some people imagine. We were not told the obvious, as we have been since, when negative results convince authors "practical trial still remains the most reliable and surest method," and "this point can only be decided by practical experience." Is it or is it not the case that our scientists are settling their minds on trifles? Do they imagine that when they discourse on such matters as "causes of mysterious fracture," "possible origination of rectangular brittleness," and "the heterogeneous character of wrought iron," they add to the knowledge and achievement of the day? Take the case of wrought or malleable iron. You cannot describe it as anything but heterogeneous, and when it is stated that a method of etching is capable of showing whether or not the pile is a mixture of good and inferior iron, or of good and homogeneous material, we ask by what manipulation can you obtain homogeneity in the ordinary commercial qualities of wrought iron? If there is to be any advantage in joining in a scheme of scientific and industrial research there is one thing certain—theory and practice must step together. All the apparatus of expensively equipped laboratories, all the text-books, all the memoirs, will not serve us in any engagement in scientific or industrial research unless it is realised that the investigations are to be made for the purposes of trade and for national profit.

B

# Loam and Dry-Sand Moulding.

By J. Shaw.

Before the Birmingham Branch of the British Foundrymen's Association, on February 26, Mr. D. Dalrymple in the chair, a Paper was read by Mr. J. Shaw on "Loam and Dry-Sand Moulding—A Comparison."

Mr. Shaw, in his opening remarks, said that in

FIG. 1.

regard to the best method of making marine-engine bed-plates, members on the North-East Coast preferred to mould in pits, with a full pattern and dry sand; but a number of the Scotch members thought the work could be done as quickly and more cheaply in loam. He therefore proposed to show a number of typical jobs recently done that might have been produced by either method. He was treating the matter from a jobbing-foundry point of view and did not claim that his methods were in any way superior, or even so good, as might be possible in a shop specially laid out for one class of work. A summary of his remarks is as follows:—

Fig. 1 shows a condenser that can be made either in dry sand or loam. This is a typical casting, and in estimating for such a casting it may be taken

FIG. 2.

that the core, with all the trappings, feet, etc., would be the same whether made in loam or dry sand. Cost comparison, therefore, is only necessary for the outside or cope. For dry sand, first must be had a body pattern; that can be made of wood, anywhere near the size, that can be lined up, or a body might be struck up in loam and the various trappings fixed to it. When rammed up, the loam body should be pulled to pieces inside the mould. In loam, the procedure can be either to strike and brick up a loam body first, fixing the trappings in and then bricking up to them, inserting the various binders and lifting plates, or to strike up direct and fix the feet, chest, etc., as the building-up proceeds.

Fig. 2 represents the starting points as the writer himself carries out the work for either dry sand or loam. There must be a flat plate with four or more lugs for fastening down and lifting, and a means for fixing a wrought-iron centre to receive the end of the striking spindle. The bottom flange is shown with the seat struck up in loam. This plate is lowered into a hole in the shop floor at a suitable depth for casting the condenser and then levelled. Fig. 3 shows the pattern lowered on to the plate, the bevel seat putting it into the correct position. A loose flange in segments fills up the struck flange and the pattern is ready for ramming up. It was found impossible to have permanent pits owing to constant change of work, and to get over the difficulty a series of rings of three diameters to suit

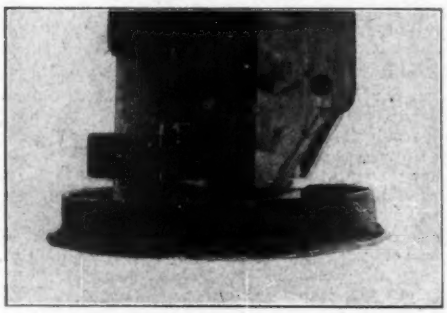

FIG. 3.

castings of various sizes was stocked. These were cast in open sand about 1 ft. deep with a flange on the top side only. Fig. 3 shows such a ring on the bottom plate, ready for the bottom to be rammed up. As they are shallow, it is quite easy to ram under the feet before putting on the next ring. It is also easy to get a level joint at any point by placing packing between the joints.

Fig. 4 shows the middle joint after the pattern has been drawn and the mould finished. The outline in white shows the inside form of the only plate required to be made for a new job. This plate has the same diameter as the flange on the ring outside and is provided with lugs to lift the whole of the top half of the mould, so that the main body core can be placed in position. The guide pins place the two halves in the right line with each other. The top half of the mould is lifted off by means of adjustable chains from the lugs on the joint plate. Each of the four chains is capable of being lengthened or shortened to the extent of a link by means of a special claw hook fitting the links. The method of fastening down is as follows:—At the top

there is a strong cross built up from steel sections which is suspended from the crane over the mould. On the bottom plate, shown in Fig. 2, there are four projecting lugs at right angles to each other. Over these lugs long slings are placed, which may be lengthened out with others if required until they rest on each arm of the cross. The latter should clear the top plate by about 1 ft. The crane, with the cross attached, is then started, and if each of the slings is taking an equal load the strain is about 12 tons. Stands are placed on the top covering plate under each arm of the cross and tightly wedged up, the core at the same time being packed down from the cross. The crane is then lowered off and the fastening down is complete.

Fig. 5 illustrates the building up of the core. This is done on a separate plate having a wrought-iron centre attached to receive the end of the long striking spindle. On the plate a level bed is struck and dried. The board and spindle being set at right angles to this bed, the core is ready to be built up. The building plate consists of a strong bottom seat plate with three wrought-iron loops cast in, and also a stop 2 in. square, against which the thirling bar is packed. Two, three or more thin binding plates are necessary, with a slot to clear the thirling bar. Also a strong top plate with lugs and holes to match the loops in the seat plate. Three 1¼ in. diameter hook bolts fit into loops in the seat plate and, passing up the inside of the core through the holes in the top plate, are screwed down to fasten the whole core together. The threads on the bolt are screwed

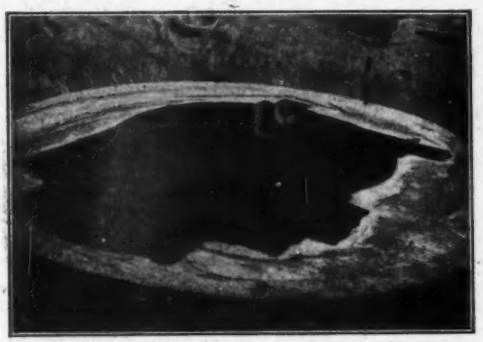

Fig. 4.

long enough to receive a cup nut as well as an ordinary nut. The core is lifted into position by means of stretching screws fitting the cups. Unless a bricked core of this size is relieved in some manner after casting, there is a tendency for the casting to fly when contraction commences. It is therefore necessary not only to provide a good clearance for the binding plates but to have one or more grooves extending from the top to the bottom of the core. Loam bricks placed over each other in each course and afterwards cut out are sometimes used, but the insertion of a thirling bar, as shown in Fig. 5, when building up saves a great amount of labour and time. This bar is packed against the stop on the bottom seat plate, and a wedge, inserted behind the wrought-iron crank fastens in each binder. The thirling bar is made with a little taper from top to bottom, being about 2 inches narrower on the face next the casting than inside the core. At the top a strong wrought-iron loop is cast in, and to this, after the casting is set and the top covering plate removed, the crane is attached. After the wedges between the cranks and thirling bar are knocked out the crane is started, drawing out the bar and leaving the groove in the core.

Fig. 6 shows the full core ready for dropping into the half-mould. The chest is either made in a separate core box or, if only one or two castings are needed, from the inside of the skeleton pattern shown in Fig. 3. Into the top core rod four wrought-iron loops are cast so that the chest can be bolted

Fig. 5.

to the main body core by means of hook bolts and suitable bars, bricks being left out of the centre core for this purpose. The joints between the two cores are made good, blacked and dried, and the whole core is lifted as shown and adjusted by means of stretching screws. That, briefly, is the method employed at the establishment with which the writer is connected for making condensers up to 5-ft. diameter and 11 ft. long in dry sand.

Before turning to the loam side of that class of work, attention may be called to another set of castings advantageously made in these rings in dry sand. The casting shown in Fig. 7 is one of twelve specially made for works dealing with explosives. They were 9 ft. long by 39⅜ in. diameter and the oblong branch was 4 ft. 6 in. by 16½ in.

Fig. 6.

The round branches were 16½ and 12 in. respectively. Taking an iron pattern the right diameter, vertical and horizontal lines were marked upon it, the latter 4 ft. 6½ in. from the bottom to corres-

pond with the centre line of the 4 ft. 6 in. branch. The full branch pattern for the 4 ft. 6 in. by 16½ in. diameter branch was made, halved in the centre of the 4 ft. 6 in. way. This was placed on the iron pattern, so that the centre lines coincided, and was fastened by means of two 1 in. set-screws tapped

FIG. 7.

into the iron pattern. The latter was then lifted up, dropped into the struck seat and rammed up in the rings, as described in connection with the condensers already shown. There was a joint at the centre of the 4 ft. 6 in. branch, and an open-sand plate casting was used to lift off the top half of the mould and to carry the sand round the pattern. Fig. 8 shows the lower half of the mould and the lowering of the 12-in. block branch into position. The long guide pins fixing the top piece into its correct place will be seen. The oblong branch and the 16½ in. core was made all in one piece with a strong cast rod which held the core in position when packed to the joint plate. The centre core, which was struck horizontally on a cast barrel, was placed in last, being lowered clear of the branch core till nearly down; the bevel seat at the bottom centred it, throwing it against the centre of the 4 ft. 6 in. core, the fine edges of the latter having previously been given a clearance. The top half was then lowered over, the cover plate put on and the whole fastened down by means of the slings and cross already described.

FIG. 8.

Next may be discussed the question of loam work for condensers. For two or three castings from 5 ft. diameter upwards, the writer prefers the loam method unless there is a pattern in stock and a good pit available. For the starting point must be had a strong bottom plate, with the bottom flange and seat struck up in loam, as shown in Fig. 2. On this seat plate the various centres for the trappings are marked. The bottom plate is covered with the first building plate, an open-sand plate with a hole and about an inch on each side larger than the body of the condenser. The outside is usually oblong, to allow the brickwork to be built round the feet and chest. This building plate is prodded on the underside to carry a level loam face, forming the back side of the bottom flange. It has also a number of lugs cast on each side, into which strong wrought-iron loops are cast. Into the latter 1¼-in. hook bolts are inserted, passing through holes in the lugs of the next building plate and so fastening together the bottom half of the mould. The spindle and board having been set to gauge sticks, building is begun.

Fig. 9 shows the building carried up to the middle joint, where the mould is parted to allow of the main body core being put in when closing. At this point the second building plate is placed, the inside being about 1 in. clear of the outline of the casting at this point, the outside corresponding and being bolted to the first plate. The chest, feet and any branches in the lower half are set to marks on the board and seat plate during the bricking up. The

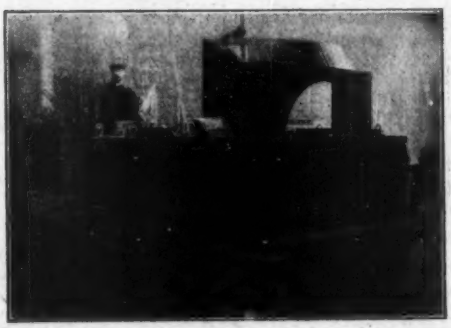

FIG. 9.

third building plate shown in the view is similar to the second, except that the lugs must not come over the lower ones, as such a projection would interfere with the screwing up of the lower half. Wrought-iron loops instead of holes are cast in the lugs, as in the first plate, for the purpose of receiving the 1¼-in. hook bolts used to fasten the top half together.

In Fig. 10 the bricking up is level with the top portion of the chest, and the patternmaker is setting the top feet on small struck beds. The brickwork is then carried to within 6 inches of the top flange, at which point the last building plate is placed. This allows for a loam brick between the plate and the underside of the top flange, which can be easily cut out if needed to allow the casting to contract. This top building plate is furnished with lugs and holes to coincide with the third plate and bolted to it, the top half being lifted from those top lugs. It is the practice for the four building plates already described to be cast in open sand, and if several castings are needed the plates are cut through the centre, so that they may be taken off the condenser without breaking, and so be used again. The joints are secured by means of strong angle irons and bolts.

The building-up being complete, the mould is struck up with loam, parted, finished, dried and blacked. The method for the core is identical with that employed for dry sand, and the mould is also closed in the manner already described, except that

in connection with the larger sizes, the cross being too small, the whole is fastened down by means of slings and hook bolts from the bottom plate passing through slots in cast-iron bearers spanning across the top of the mould, the hook bolts being well screwed up.

The brickwork with so few building plates is not strong enough to resist the pressure of the metal, and this calls for special treatment. This may be effected either by means of special arrangements in the building plates, and particularly by an increase of their number and the casting of strong prods round the outer edge; or a series of square holes may be provided round the outer edge through which strong cast bars should be inserted and loamed close. Even then the mould is better cast in a pit and the sides well packed to it, with the lower half rammed up for two or three feet. As the writer has at his disposal no permanent pit, it is the practice to ram the outside up in strongly ribbed open-sand plates, cast on the pig-bed direct from the furnace. These are holed so that a pit up to 11 ft. square can be made. In a number of cases where the mould was too heavy for the cranes these plates were used to form a temporary pit and the job built in position with very few building plates, drying being done by means of a gas flue carried down to the bottom.

FIG. 10.

There is a general impression that loam moulding is always costly, but Fig. 11 illustrates the fact that that is not the case when compared with many jobs now made in dry sand. Of course, there must be enough to pay for the proper lay-out. The illustration is that of the preparation for making slag pans previously made in dry sand. The pans were 7 ft. by 3 ft. 6 in. by 3 ft. 6 in. and weighed 45 cwt. The only pattern used is the skeleton frame shown in position round the core casing in the top of the view. Upon this are marks to which the outlet branch and the eight brackets are set. The plant consists of a cast-iron core casing, ¾ in. on each side less than the mould should be, and this space is filled with loam strickled off with strickles working on the skeleton frame. The lower part of the view shows the outside casing with the same loam space and the various pockets to receive the turning-over brackets and spout. The four lower brackets and the inside of the spout are formed with cores. The same skeleton pattern turned over is dropped centrally in the outer casing, loamed and strickled off. The two halves are then dried and blacked, the core casing turned over on a bank of sand and then closed to guide marks.

Another example which may be mentioned was an order for 100 half pipes. The complete pipe was 48 in. diameter inside and 6 ft. long. The end flanges were external and bracketed, while the horizontal flanges were internal. As they were made at the rate of one per day by an apprentice and a labourer, it will be admitted that the lay-out was good. Fig. 12 is a view of the whole of the plant. At the bottom there is the cope or outer casing. This is made by striking up in loam and dividing with a 1½-in. splitting core, as shown in the sketch Fig. 13.

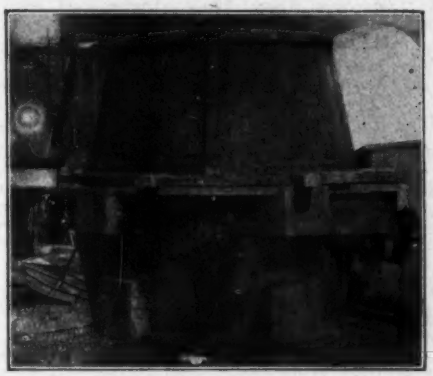

FIG. 11.

The flange at A bolting together forms the whole casing. The recess at C is to take the flanges. At the ends B a semi-circular plate is bolted with a 2-in. half-hole to receive the spindle. This is clearly shown in Fig. 12, also the board which strikes the circular part of the mould, with the flanges and prints for the main core. This board is shown at the top of the view and the outline of the flange and bracket is chalked in. The bolt holes and brackets are formed by four cores.

With regard to the core casing, the chief difficulty has to do with the horizontal flanges. This is overcome by having a central D-shaped casting, the remainder of the half-circle being made up with a loose segment at each side, one of which is clearly shown in Fig. 12. These segments are secured to the main piece by cotter bolts inserted through the slot holes shown in the view and cottered up from the inside. The ends of the segments come iron to iron on the bottom plate at the end but leave space enough for the internal flange to be rammed up for the full length. At the ends of the D-shaped portion circular guides are bolted. These are 48 in

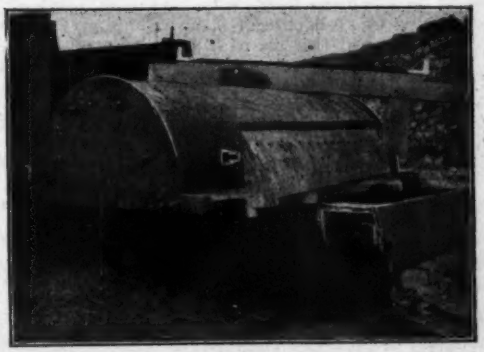

FIG. 12.

in diameter and have projections at half-way, from which the horizontal joint is struck. The operations are as follows:—While the casing is still hot the horizontal joint is struck right to the root of the

D-shaped portion of the casing. On this joint the loose internal flange patterns are placed and set to position. The loose segments are next cottered up and the space between the loose flanges and the segment rammed up in red sand. The core casing is then loamed over and struck off with a straight edge worked over the end guides, the thickness of the loam (¾ in.) being clearly shown at the end of Fig. 12. When finished, dried and blacked the core is turned over on the trunnions, cast in the guide plates and closed into the cope by lines cut at the ends of the flanges, the print setting it true sideways. After casting, the bolts and cotters are withdrawn from the segment, which liberates the bottom plate and D-shaped section of the core casing.

### Discussion.

The PRESIDENT, in opening the discussion, said that loam moulding was a specialised branch which all moulders had not had an opportunity of acquiring. He thought one of the chief advantages in loam moulding was in the making of very large castings, without incurring much expense in pattern-making, the apparatus used being of a simple description, consisting of spindles, bars and striking

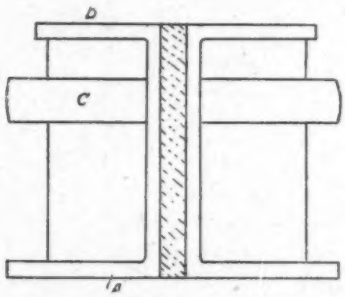


FIG. 13.

boards, and used in a similar manner to that in which a pattern-maker would run up plaster patterns in the light-casting trade.

MR. R. BUCHANAN remarked that the lecture was very useful in indicating the conditions under which either method was advisable. That depended largely on the question whether the worker was making "running" work or was operating under jobbing conditions. He could not help congratulating Mr. Shaw on having produced such very large castings, especially the condenser. Some of his own early experience had to do with loam moulding; the loam moulds were rammed up to the top and the ramming was done very soundly, and he remembered what laborious work it was. Once, when dealing with a very large casting, he had to stick to that work for three days, and he was very glad when the ramming reached the top of the bed. In recent years he had seen a casting taking 14 tons of metal dealt with without any ramming whatever. In the North of England it was the practice to make propellers in loam and cast them in the open without ramming, and that was a class of casting which in the old days was rammed up very faithfully. That practice, of course, added very considerably to the cost, and he had no doubt at all that the castings now made and produced without the ramming were much more cheaply done. There must be a great saving in dispensing with labourers ramming up for three or four days.

MR. I. I. HOWELL remarked that with regard to the core employed in the condenser, Mr. Shaw did not say whether he filled up the inside of the core or not. The hot air would greatly expand, and if the inside of the core were not rammed up he thought it quite likely an explosion might take place, which would loosen the bricks. It seemed to him that the loam bricks were very near the danger zone. But he should suppose that leaving a gap of 12 inches would be a very effective precaution. The arrangement of those pieces to provide for the pulling of the metal, so as to reduce the strain appeared to be a very good idea.

MR. WILLIAM JAMES asked Mr. Shaw whether it would be advisable to strike the body core upon the plate with two loops in, instead of striking the core on a barrel or core bar?

MR. SHAW, replying to the discussion, said the President had mentioned the saving of expense in pattern-making, and while, with timber at its present price, that point was worth considering, it did not affect the advantage of the two last examples. In fact, if the patterns were given in, he questioned if they could be made for twice the cost in dry sand. With regard to Mr. Howell's question, he made no special provision for gas escape from the core. The man who was skimming the metal threw a few drops of molten metal down the inside, and this ignited the gas at the start. They rammed the core up for about 1 ft., to make sure there was no leakage round the seat joint. The last large core shown was 12 ft. 6 in. long by 7 ft. 6 in. diameter, was double-bricked for about 3 ft. up, but only single-bricked, with pillars, for the remainder of the height. There was seldom trouble with the straining of the bricked core, but the outside needed more care for this cause. A member suggested making the 39⅜-in. core with plates and rods; but he could strike the barrel core up for less than he could make the rods, let alone make the core. With regard to Mr. Buchanan's question as to how he dried the biggest job exhibited, the producer-gas flue was carried under the bottom plate, a large circular burner fixed to it and the whole mould formed a large stove.

The meeting concluded with a hearty vote of thanks to Mr. Shaw for his Paper.

## Correspondence.

### Works of Mild Steel Castings, Limited.

*To the Editor of* THE FOUNDRY TRADE JOURNAL.

SIR,—I shall be glad if you will correct an erroneous statement which appeared in your journal of March, 1916, under the title, "Works of Mild Steel Castings, Limited." The paragraph referred to appears on page 132, and conveys the impression that Mr. W. H. Watkins and Mr. W. S. Knight have been general manager and works manager respectively for the last five years. The facts of the case are as follows:—The furnace which the Mild Steel Castings, Limited, state is their patent was invented by me in 1908, and is known in the text books and the trade as the "Miller" furnace. The company took over the rights, I being appointed works manager. On removing from Wellington, Salop, five years ago, Mr. W. H. Watkins was appointed as my assistant, and held this position until May 19 last, when my connection as works and commercial manager terminated. It was not until April of last year that Mr. W. S. Knight appeared on the scene, and held no definite position under me.

Yours, etc.,

WM. MILLER,
(Manager for Steel Castings (Giles Foundry), Ltd.).
West Bromwich,
March 21, 1916.

# Carbon—Temperature—Iron.

Before the London Branch of the British Foundrymen's Association, on March 17, Mr. E. Adamson (Sheffield) lectured on the subject of "Carbon—Temperature—Iron." Mr. A. R. Bartlett occupied the chair.

At the outset, the lecturer referred to the question of grading pig-iron by analysis—the system so much advocated in America. At the Copenhagen meeting of the International Association for Testing Materials, he recalled, the United States and another country put forward a strong proposal to adopt the grading by analysis system in Great Britain. A committee of practical, technical and commercial men was appointed to consider the matter, and that committee reported against the proposal, the only support being received from the members who had had no practical training. At the New York meeting of the Association a Paper on a method which practically amounted to silicon control was presented; but he (the speaker), in a written contribution, gave facts and figures which were definitely against that suggestion. One ardent American supporter of analysis grading admitted ultimately that the method did not take into proper consideration the condition of the carbon. It was, further, an interesting fact that in the United States, although analysis was depended upon to such an extent, ironfounders did take into consideration the fracture appearance of the pig-iron they used. He (the speaker) recalled the case of one American user of British irons who had formerly insisted on low phosphorus, but who, on being shown the test results of irons with varying phosphorus, readily accepted P. 1.0 per cent.

Very considerable variations were possible in the different constituents, taken individually, with the same strength. He had obtained practically the same transverse-test results with 3 per cent. Si. as with 1 per cent. Si. in another iron. In one case a bar containing 3.18 per cent. Si. had given 32 cwts. and 0.8 in. deflection, while 0.6 in. deflection had been frequently recorded with that percentage of Si. Further, solid castings could be obtained with similar variations in analysis; and it was also possible to have similar fractures and grain in irons containing 3 per cent. and 1 per cent. Si. respectively.

Coming to the question of temperature, Mr. Adamson quoted the remarks of Mr. E. L. Rhead on the strength and properties of cast iron.* Mr. Rhead stated that "the most suitable temperature for casting is that which will allow the mould to be completely filled with molten metal, which, when the mould is full, still retains all its constituents in completely fluid solution, and all preparations as regards metal and gates must be made to that end. It is not only unnecessary but inadvisable to heat the metal beyond that temperature, since the longer period of setting prolongs the period during which the casting is weak, gives opportunity for the formation of coarser graphite, and the formation and transference of the most fusible eutectic possible in the iron used, with the formation of shrink holes and local weakening where it has been withdrawn. . . . It would appear that for every type of metal and for every casting there is an ideal pouring temperature at which the slowness of the cooling shall not lead to the separation of coarse graphite with consequent loss of strength."

Without disputing this, the question might be asked, "How is all this to be done in the jobbing shop?" In cupola working the control of pouring temperatures was a difficult matter; at the outset the metal was chilled and hard, but it got hotter and hotter during the melt, and if the furnacemen were not careful it would get colder again towards the end of the blow. In practical working the metal temperatures had to be taken as they came. Similar variations occurred even with melting in the open-hearth furnace. An interesting example of the pouring temperatures adopted was that of the practice in the works of one of the largest and most up-to-date Swiss firms, where the metal was poured as hot and quickly as possible. It was common English practice to allow the iron to cool down in the ladle to the temperature which was deemed best for the mixture and casting, and probably with the irons used that was a good procedure to follow.

In discussing the question of carbon in the past he had frequently made use of the terms temperature and time; but the significance of the terms

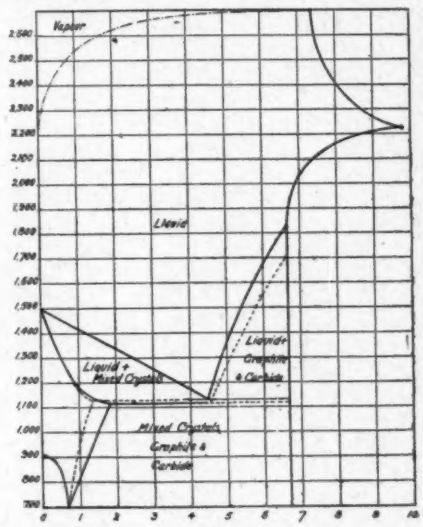


FIG. 1.—IRON-CARBON DIAGRAM.

had been quite misunderstood. In criticising his contentions it had been commonly assumed that the temperature of casting and the rate of cooling on pig beds were the matters in question. In using the terms "temperature" and "time" in reference to the influence on carbon in iron, however, he referred to the conditions inside the blast furnace, *i.e.*, the temperature of the furnace and the duration of contact of the iron with carbon. On these fundamental considerations rested the whole question of carbon and its condition. A commonly accepted assumption was that iron (Fe) would not take up more than about 4.25 per cent. of carbon, hematite iron, for example, having generally about 4 per cent. C. The fact that under ordinary conditions about 4.25 per cent. represented the saturation point had been fixed upon as the basis for many misleading conclusions, for actually iron would take up much more carbon, given the necessary temperature. This was shown by the iron-carbon diagram (Fig. 1) as extended by Ruff and Goecke. By heating iron in an electric

* See "Foundry Trade Journal," February, page 92.

furnace in contact with carbon for a protracted period, then chilling the iron by dropping it into water, it was found that with increase of temperature carbon continued to be absorbed, until at about 2,220 deg. C. it was found to contain about 9.75 per cent. C. On further increasing the temperature the carbon content was found to decrease. The practical significance of this fact was that the temperature to which the iron was raised in the blast furnace influenced the amount of carbon taken up. The temperature at which it left the furnace was not the smelting temperature, nor necessarily the temperature of the metal as it lay in the well of the furnace in contact with carbon; and the higher the temperature and the longer the contact with the coke, the greater the carbon absorption would be. If, then, 5 or 6 per cent. C. were absorbed in the furnace, when the metal cooled down to normal temperature it threw out of solution the excess carbon as free graphite or "kish." Such kish could often be found on the surfaces of pig-iron, and the lecturer exhibited a sample of the graphite in question which had been gathered from pigs after casting. When a kishy iron was remelted in the cupola the kishy or loose graphite was not necessarily blown out with the blast, but largely went down with the molten metal to the well and the resulting metal in the ladle lacked the clean "break" on the surface which founders liked to see, but instead there was a dirty, greasy appearance on the top of the metal.

He once investigated a case of carburised metal from the cupola, when the quality of certain hematite iron was called into question. The cupola was small for the total quantity required and the first ladle of metal had to remain standing for three hours before casting. In order to keep it hot, carbon dust (blacking) and coke were put on top of the molten metal. The result was that the metal was taking up carbon the whole while, which probably remained in suspension, whilst apparently some of the carbon in the metal separated out and the flakes of graphite increased in size, and the presumed carbon content was therefore greatly exceeded. In the ingot moulds cast therefrom there was a huge hole under the top skin, containing a large quantity of kish.

An important point to remember was that Temperature × Time = Total Carbon, and also affected the character of the carbon. Also, within certain limits increase of one factor and decrease of the other gave similar results, *i.e.*, (+ Temperature) × (— Time) = $x$ and (— Temperature) × (+ Time) = $x$, where $x$ represented total carbon. Similar formula, of course, applied to cooling and carbon separation in malleable iron castings. Time and temperature of contact with carbon, therefore, played a prominent part in governing the physical properties of the metal. The cupola conditions as well as the blast-furnace conditions could influence carbon absorption. He had met a case where irons charged had 3 per cent. C. and had held over 4 per cent. C. on tapping from the cupola. The cause was traced to the use of 50 per cent. of "black ends," *i.e.*, improperly burned coke, in the coke charged, while further, the blast pressure was reduced to slow down the rate of melting to keep pace with the moulding capacity. As a result, carbon which should have been combusted got into the metal instead.

As an example of how fracture appearance could be misleading, the lecturer showed photographs of two fractures of the same pig, that at the sow end being a typical No. 1 and that at the nose end No. 4. The normal fracture should have been No. 3 or No. 4, but the pig probably came from the top of the bed, and the flow of metal past the sow end while the rest of the bed was being filled kept that end of the pig hot long enough for abnormal separation and growth of graphite.

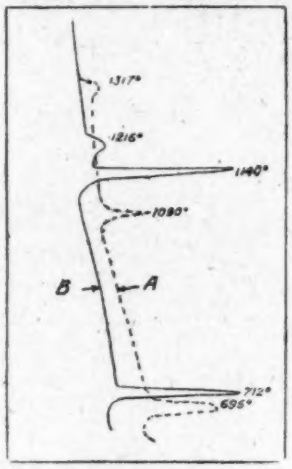


FIG. 2.—COOLING CURVES OF IRONS "A" AND "B."

A further general assumption which he did not consider correct was that all the graphite in an iron went into solution on remelting. He instanced as against this assumption some experiments of his own with two irons of practically the same total carbon and very similar contents of other constituents but of different sources of origin. The analyses were:—

| | T.C. | C.C. | G.C. | Si. | S. | P. | Mn. |
|---|---|---|---|---|---|---|---|
| A ... | 4.20 | 0.58 | 3.62 | 1.02 | 0.018 | 0.022 | 0.53 |
| B ... | 3.90 | 3.90 | trace | 1.04 | 0.010 | 0.018 | 0.22 |

"A" was a No. 1 hematite, and "B" was an alloy made from Swedish white iron and high-grade ferro-silicon. In these two irons practically the two extreme forms of carbon found in grey and white pig-irons were present. The metals were raised to 1,500 deg. C., and cooling curves taken. An examination of these indicated that No. 1 pig-iron contained a good proportion of its carbon as free graphite in suspension when molten, as its separation during solidification was not evidenced to nearly the extent it should have been if it were true that all carbon in molten iron was in solution. The conclusion he arrived at was that large-flake graphite, such as was characteristic of No. 1 pig, was not dissolved entirely in the course of melting in the cupola. It was, indeed, common knowledge that an open-grained iron was not converted into a close iron in once melting.

It was a practical deduction from the foregoing that cold-blast iron should have a lower total carbon content and a closer grain than hot-blast iron. The higher the temperature at which the iron was made, the more open would it be; and open-grained iron gave open-grained castings. His (the lecturer's) opinion on the distinction between graphite in its different forms was confirmed by Moissan's experiments. Moissan produced diamonds from carbon in the electric furnace, and amongst other things recorded that when graphite came into contact with an oxidising atmosphere it swelled. It was probably the case that oxidising gases in molten metal caused the carbon to slightly swell, which in the semi-fluid state caused a vacuum between the grains of iron.

It was hardly correct to say that carbon was the key to the question of grading; for there was no one key. But it was safe to say that chemical analysis alone, as usually applied, was not reliable, while fracture grading was also unreliable, unless the man applying it was very well versed in the conditions which produced fracture or had had long cupola experience. As to silicon control, that was also unsound; and in support of this he showed analyses of two irons with respectively 0.35 per cent. Si. and a No. 1 fracture and 0.32 per cent. Si. and a white fracture; also tables showing varying C.C. with the same Si. content and varying Si. with unaltered C.C. content, all from normal works condition. Various sets of figues by different writers were quoted to show that silicon did not, as was often contended, control the combined carbon.

### Discussion.

Mr. R. T. Rolfe, in discussing the practical application of Mr. Adamson's remarks and the effect of casting temperatures, referred to certain experiments he (Mr. Rolfe) had made in the past. Longmuir had similarly experimented with different casting temperatures and had found that with gunmetal a mean of 1,069 deg. C. gave the best results, while with white iron 1,200 deg. C. was found to be best. Hatfield's experiments did not confirm this, for he found the results erratic; though rather better results were got with the higher temperatures. His (Mr. Rolfe's) own experiments with gunmetal showed that from 1,100 deg. down to 1,000 deg. C. gave no real difference. The conditions of the experiments would, of course, affect the conclusions. Cast iron, anyhow, represented a gamble; and he agreed that both chemical analysis and fracture appearance were useful, but only as guides in judging iron.

Mr. Adamson said that, in regard to casting temperatures, if test-bar results were wanted the hotter the metal was cast the better; but if solid castings were required the casting temperature should be chosen to suit the thickness, etc., of the casting. When both requirements were in view it was best to cast the test bars where they would cool most rapidly. Silicon and combined carbon, he would say, were certainly somewhat related, but only in a general way, and silicon did not *control* the percentage of combined carbon.

The Chairman (Mr. A. R. Bartlett) recalled the casting of a heavy hydraulic cylinder from which test bars were required. As an experiment he cast a series of six bars, the first with metal direct from the furnace and the others at 5-minute intervals. The best bars were those cast first. The cylinder was cast at a different temperature, and the bars which were attached (near the bottom) were not nearly up to the bars cast first from the hot metal. Did the lecturer think that cooling before pouring weakened the metal? Also, what was the effect of aluminium when used to keep the metal hot? He agreed with a remark by the lecturer to the effect that for casting in chills the hotter the metal the deeper the chill. Should castings to stand continual heating have high or low total carbon, and what general analysis was suggested? Would the pressure of the blast affect the contents of the metal? Finally, what change in melting would be expected in the following mixture:—T.C., 3.4 per cent.; Si., 1.5 per cent.; S., 0.042 per cent.; P., 0.6 per cent.; Mn., 1.1 per cent.?

Mr. W. Ellis asked what class of metal would be required for fan casings, which had to be dead soft and sound?

Mr. J. Stone said he was once induced to try for malleable cast-iron an iron with 2 per cent. of phosphorus. The metal, however, broke off like a carrot. As to grading, he gauged by fracture appearance alone. Did the lecturer agree with the use of steel in a mixture for malleable cast iron?

Mr. Barrett recalled the casting of certain very thin marine cylinders which were found very hard when being bored. A stick of aluminium was suspended in the runner during pouring, and the casting came out much softer.

Mr. Adamson, in reply, said that test bars were no criterion of the strength of the castings which they were supposed to represent. He had founds castings which gave only one-third the test results shown by their test bars. In one instance a test piece cast on the boss of a propeller gave 4½ to 5 tons instead of over 11 tons as expected and regularly obtained, this result being caused by the heavy boss prolonging the cooling and giving an open grain. If hot metal were allowed to cool down before pouring it would be weaker by reason of graphite separating out. The action of aluminium in cast iron was to make it greyer, though the actual nature of this influence was uncertain; but the greyer the iron the softer. Resistance to heat was more a matter of physical characteristics than chemical composition. Cold-blast irons had physical properties which favoured their use for castings to resist heating. If cold-blast and hot-blast irons of the same analysis were cast into fire-bars, the life of the cold-blast bars would probably be as four to one compared with the hot-blast bars. Regarding the absorption of carbon in the cupola, if well-burnt coke were used a little might be taken up, but with badly-burned coke a lot would be absorbed. The pressure of blast and the length of time the metal lay in the well of the cupola would affect the composition. A charge comprising 50 per cent. mild steel and figuring out to a total carbon of 1.75 per cent. might show 3 to 3.25 per cent. C. at the tapping spout. As a rule the higher the blast pressure the less would be the carbon absorbed in melting. The change to be expected in the analysis quoted by Mr. Bartlett was possibly a slight increase in the carbon, a reduction of the silicon from 1.5 per cent. to 1.25 or 1.3 per cent.; an increase in the sulphur from 0.042 per cent. to 0.05 per cent.; an increase in the phosphorus from 0.06 per cent. to about 0.063 per cent.; a reduction of the manganese from 1.10 per cent. to 0.90 per cent. For fan casings the metal required to be thin and liquid, and low in combined carbon, containing all that element as free carbon if possible; but it should not be too open. If a No. 1 iron could be got to run and give a good surface it would be the iron to use. As to mixing irons, if a No. 1 and a white iron were melted, say, equally together they would on being left standing in a molten condition separate out, the white iron going to the bottom and the grey to the top. The same occurred with steel and grey iron when mixed. He was sorry for the man who recommended for malleable cast iron work an iron with 2 per cent. of phosphorus. In American black-heart practice up to 0.25 per cent. phosphorus was sometimes used, as it was not found to be detrimental and helped the running. But that was far below the amount in question. In malleable work quite good results could be got by mixing all grades from grey to white so long as the casting before annealing came out white. The thinner the castings the softer should be the mixture. Incidentally he recalled seeing a founder successfully using stove-grate scrap to harden grey-iron castings.

# The Endurance of Metals under Alternating Stresses.*

By B. Parker Haigh, D.Sc.†

Tests for the endurance of metals under alternating stresses have seldom been specified as proving tests, and seem unlikely ever to form part of the regular series of tests imposed by specification. Under present-day conditions they fall into the category of experimental research, chiefly on account of the delay which would be occasioned if deliveries were held back for the completion of lengthy fatigue tests. With the knowledge at present available, it is impossible to anticipate the result of a fatigue test under alternating stress, from the proved values of the ultimate tensile or shear strength, or Brinell hardness. In the writer's experience the performance of steel, as regards

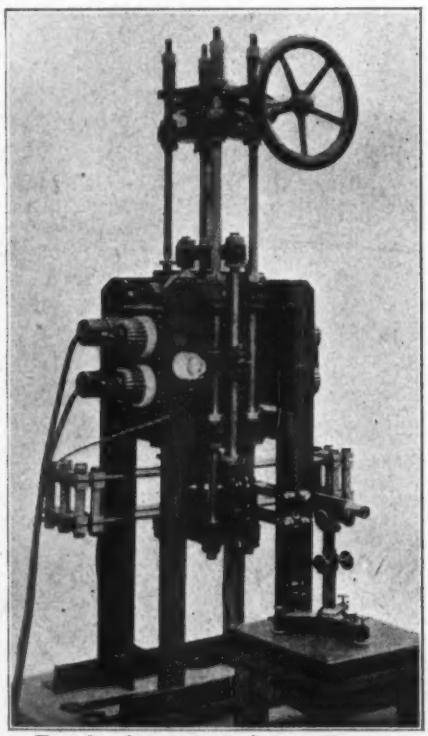

FIG. 1.—ALTERNATING-STRESS TESTING MACHINE.

resistance to fatigue, is generally better than that of alloys of comparable strength. It may reasonably be hoped that a relation will eventually be found between the limiting range of stress above which fatigue is liable to occur, and the other physical properties of the metal; so that the fatigue limit may be deduced from the ordinary proving tests without carrying out lengthy tests under alternating stress.

The testing machines used in researches with alternating stress differ chiefly in the kind of stress applied, viz., alternations of direct tension and compression, torsion, plane bending, and rotary bending. A brief description of some of the devices employed in different machines may be of interest. Rotary bending machines have been used by Woehler, Sir Benjamin Baker, and by several later investigators. Plane bending machines have been devised by Woehler, Capt. Sankey, and by Prof. Arnold. Woehler's machines operated with only a low frequency, about 60 per minute, and would hardly be used to-day on account of the time required to complete a test. Nevertheless his work, which covered some 12 years and was continued by Bauschinger and by Spangenburg, yielded a great deal of information and formed for many years, with Sir Benjamin Baker's investigations, the only record of experiments with alternating stresses. To enable higher frequencies to be employed, and thus reduce the time required to carry out a test, a machine using the force of inertia to produce the load on the specimen was designed by Prof. Osborne Reynolds. In another high-speed machine, designed by Prof. B. Hopkinson, inertia forces are used to develop the stress applied to the specimen, but are generated with trifling expenditure of energy by means of mechanical resonance.

In a novel form of testing machine devised by the writer, an alternating-current magnet is employed to generate the whole of the pull applied to the test piece, without the agency of resonance.

A small machine designed for wire testing was made in 1910 from designs approved by Prof. Arch. Barr, and was installed in the James Watt Engineering Laboratory of the University of Glasgow.

The chief difficulty in designing an alternating-stress testing machine lies not so much in producing the alternating stress as in measuring its intensity. A large alternating-stress testing machine, designed by the writer and installed in the Engineering Laboratory of the Royal Naval College, Greenwich, operates on the same principle as the small wire testing machine, but is fitted with two-phase magnets so that specimens may be tested under stresses ranging between equal intensities of tension and compression. Provision is also made for testing specimens under combined stresses, an alternating stress being then applied simultaneously with a steady load of tension or compression. The complete machine is shown in Fig. 1 and its diagrammatic arrangement in Fig. 2. The two magnets $M_1$ and $M_2$ alternately attract the armature A upwards and downwards respectively, the pull of the one being at its maximum when the pull of the other is zero. The armature is coupled to the lower end of the specimen S, of which the upper end is held in an adjustable fitting attached to the framework which carries the magnets.

The inertia force required for the acceleration of the armature is provided by a spring CS connected between the armature and the frame, and adjustable in stiffness according to the frequency at which it is desired to carry out a test. By extend-

* Abstracted from a Paper read before, and printed in the "Transactions" of, the West of Scotland Iron and Steel Institute.

† Royal Naval College, Greenwich.

ing or compressing this spring, the specimen is subjected to a steady load of tension or compression, in addition to the alternating stress produced by the magnets. In operating the machine, the position of the upper end of the specimen is adjusted so that the air gaps between the armature and the two magnets are equal, this being indicated when the currents taken by the two magnets are the same. The pull is measured by the voltages induced in secondary coils wound close to the polefaces, the machine being standardised in a special manner by means of a cylindrical phosphor-bronze specimen fitted with an extensometer.

The cyclical variation of the load on the specimen may be studied by watching the vibration of the index levers of the extensometer, a stroboscopic disc being interposed between the vibrating index levers and the objective of the microscope. The disc used had four slots and was rotated by a small four-pole induction motor supplied with alternating current from the mains feeding the magnets. Rotating with a slight slip, i.e., slightly below synchronous speed, the disc showed the vibration of the index arms as if that occurred at a low frequency instead of at the real frequency of 2,000 per minute. The movement was found to be very approximately simple harmonic, showing that the stress applied to the specimen varied in a sine wave, without appreciable harmonics.

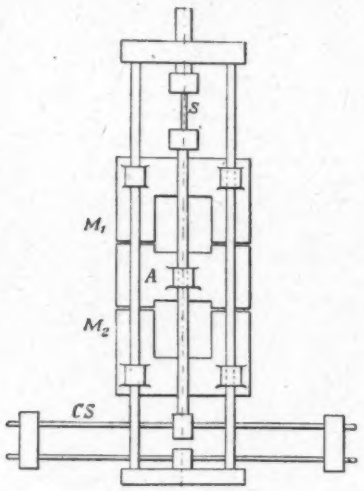


FIG. 2.—ALTERNATING-STRESS TESTING MACHINE.

The form of the specimens used in tests made in this machine is shown in Fig. 3. A plain cylindrical specimen is naturally to be avoided for endurance tests, since fatigue would inevitably commence at the ends, the stress there being greater than the average value, calculated from the measured diameter. The actual specimens used were turned with short cylindrical portions about ½ in. in length, at the mid part of their lengths, and were tapered towards the ends, with gradual transition curves between the conical and cylindrical portions. By adopting this form it was practicable to measure the diameter accurately; and as almost all specimens fractured within the cylindrical portions of their length, the value of the stress calculated for that section could be taken as that which had produced fatigue. Precautions were taken in gripping the specimens (which had screwed ends) to ensure that no initial stresses, either of torsion or bending, were applied in tightening up the locknuts.

The machine described above has been in use in the Engineering Laboratory of the Royal Naval College, Greenwich, for some time past, and has been used by the author in connection with several researches on steels and alloys.

### Swedish Wrought Iron.

As the results obtained in some experiments with a steel of fair quality were somewhat inconsistent among themselves, an investigation was carried out to ascertain to what degree the endurance of the metal was affected by cold working and by heat treatment. Swedish wrought iron was employed in these tests in order to isolate ferrite, the chief constituent of mild steel. The metal used was of good quality, rolled in ½-in. bars and was annealed before making the tests, although tensile experiments showed that the effect of annealing was only slight.

| | |
|---|---|
| Yield stress, tons per sq. in. ... ... ... | 11.8 |
| Ultimate strength, tons per sq. in. ... ... | 19.4 |
| Elongation, on 21 diameters ... ... ... | 20.3 per cent. |

The fracture was somewhat cup-shaped, indicating freedom from slag, and this was further shown by microscopic examination. The structure of the metal was almost entirely ferrite, with small and finely divided particles of slag.

Three series of tests were carried out with alternating stresses in order to compare the effects of the following treatments. In each series of experiments the stress varied between equal intensities of tension and compression, and the frequency was maintained at 2,000 cycles per minute. (1) No treatment—annealed metal. (2) Similar specimens strained by direct tension, the load being regulated in each case so that the elongation was the same, viz., 10 per cent. It was not found that the load required varied. (3) Similar specimens,

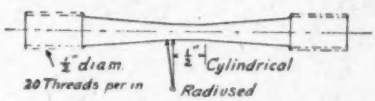


FIG. 3.—SPECIMEN FOR ALTERNATING-STRESS TEST.

strained in the same manner and subsequently boiled in water at 100 deg. C. for 30 minutes to restore elasticity.

It was found that the results of each set were highly consistent among themselves, but that the fatigue limits indicated by the three differed appreciably. The endurance was considerably increased when the metal had been strained, and was further increased when the strained metal had been boiled. In the three series, the ranges of stress which produced fracture after three million repetitions of stress were respectively 20.(0) —— 23.(0) —— and 26.(0) tons per sq. in. There appeared some doubt as to whether even these values of the range could be regarded as true fatigue limits, for the slope of the endurance curve was appreciable, even after three million cycles. It was suggested that the effect of straining and of subsequent boiling might be not so much the raising of the fatigue limit as the improvement of the endurance when the range of stress exceeded this limit. To settle this point would clearly require the expenditure of a great deal of time, and up to the present no opportunity has presented itself for this.

Under stresses sufficient to produce fracture with less than, say, 100,000 cycles at 2,000 per minute, appreciable warming was observable in the case of each set of specimens. Thus the sense of touch serves to indicate the range of stress at which to begin any such series of experiments.

### Structural Steels.

To show the variations that occur in ordinary qualities of steel used in structural and mechanical practice, tests of two samples may be quoted, the one a mild steel and the other a stronger Bessemer steel containing about 0.35 per cent. carbon. The metals were tested in the condition in which they were received without being annealed, so the results may be taken as applicable to practice. They may be summarised as follows:—

| Material. | Mild steel. | Bessemer steel. |
|---|---|---|
| Yield stress, tons per sq. in.... | 22.8 | 36.5 |
| Ultimate strength ... ... | 28.7 | 44.7 |
| Elongation on 20 diameters ... | 24.4 per cent. | 15.4 per cent. |
| Reduction of area at fracture | 73 ,, | 48 ,, |
| Limiting fatigue range, T/in.$^2$ | 33.5 | 35.0 |
| Ratio, $\frac{\text{Semi fatigue limit}}{\text{Ultimate strength}}$ | 0.62 | 0.410 |

It is remarkable that the fatigue limits of the two metals should be so nearly alike, although the tensile strengths and yield strengths differ so widely. The value of the ratio between the fatigue limit and ultimate strength varies widely, and without further data than has yet been collected, the author finds it difficult to suggest any relation between the two strengths. It is probable that the effects of other elements than carbon present in the metal are important, and Dr. Stromeyer has suggested nitrogen. It is desirable to accompany fatigue tests with very accurate measurements of the modulus of elasticity of the specimen. The sensitive measurement of the modulus is, however, a matter requiring delicacy of manipulation, and would be difficult to accept as a regular proving test.

The rise of temperature met with in Bessemer steel, when the range of stress exceeds the fatigue limit, appears greater than in mild steel, and this may be due to shearing proceeding between the laminæ of pearlite instead of between the opposite faces of slip bands in the ferrite. In a series of tests on the Bessemer steel referred to, a load of tension was applied to produce a stress of 9.45 tons per sq. in. in combination with an alternating stress. This corresponds to a factor of safety of 4.5 reckoned on the ultimate strength of 42.7 tons per sq. in. and is well within the elastic limit at about 22 tons per sq. in. The limiting fatigue range under these conditions was found to be 32.5 tons per sq. in., a considerable reduction from that found for a pure alternating stress.

### Mild Steel under Combined Alternating and Steady Stress.

The material employed in this research was supplied as "dead mild" steel, in the form of 9/16-in. rolled bar. It was not annealed before testing, but was used in the condition in which it was received from the rolling mill. The results of tensile and Brinell hardness tests are summarised in the following table:—

| | |
|---|---|
| Diameter of specimen ... ... ... | 0.374 in. |
| Elastic limit ... ... ... ... | 18.3 |
| Yield stress ... ... ... ... ... | 21.0 |
| Ultimate strength ... ... ... | 25.2 |
| Elongation on 6 in. ... ... ... | 20.5 per cent. |
| Reduction of area at fracture ... ... | 71.4 ,, |
| Brinell hardness number 104 kg. /mm$^2$—66 tons/sq. in. | |

The Brinell test was made by means of a standard 10-mm. ball pressed upon a plane surface with the standard load of 3,000 kg. Alternating stress tests were arranged in seven series, viz., one with stresses ranging between equal intensities of tension and compression; three with different intensities of steady tension combined with varying ranges of alternating stress, and three with different degrees of compressive stress applied simultaneously with alternating stress. In this way seven values of the limiting fatigue range were obtained, each corresponding to one particular value of steady stress. The duration of the tests followed by fracture varied from a very few cycles up to eight million. Other tests were continued beyond this number, in one instance to 17 million cycles without fracture. It may be doubted whether even the longest tests indicate an absolute fatigue limit, but the asymptotes were at least sufficiently clear to indicate a fairly definite value. These values are given for the several series in the following table:—

| Series. | Steady stress. Tons per sq. in. | Limiting range of alternating stress |
|---|---|---|
| O. ... ... ... | Nil | 26.0 |
| I. ... ... ... | 4.95 | 24.5 |
| II. ... ... ... | 9.87 | 21.5 |
| III. ... ... ... | 12.80 | 17.5 |
| IV. ... ... ... | - 5.21 | 23.5 |
| V. ... ... ... | - 9.35 | 21.5 |
| VI. ... ... ... | - 12.20 | 19.5 |

The ratio between the semi-range of stress, required to produce fatigue without a simultaneous steady load, to the ultimate strength of the material is approximately 0.51, somewhat lower than in the mild steel quoted earlier, but still in accordance with what may be anticipated in a dead mild steel.

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**PRESENTATIONS TO B.F.A. BRANCH PRESIDENTS.**—At a recent meeting of the Scottish Branch of the British Foundrymen's Association at Glasgow, when Mr. Matt. Riddell (Branch President) occupied the chair, presentations were made to Professor Campion and Mr. W. Mayer, past-presidents of the Scottish Branch. Mr. Riddell, in making the presentations, referred to the formation of the branch and to the work which those gentlemen had done. He asked Mr. Mayer to accept from the members of the Branch a solid-silver fruit bowl as a token of the high esteem in which he was held by them, and also of their appreciation of his valuable services to the association. Mr. Mayer, in acknowledging the gift, said he had found great pleasure in the work which had been given him to do, and hoped, so long as he was able, to place any services he could render at the disposal of the Scottish Branch. Mr. Riddell then asked Prof. Campion to accept a cutlery canteen as a token of the high esteem in which he was held by the members, and also of their appreciation of his valuable services rendered to the association. The idea of instituting a Scottish Branch originated from Prof. Campion's students in the Royal Technical College, Glasgow, and the professor was responsible for putting the Branch on the proper lines. Since the inauguration he had placed his scientific knowledge at their disposal, and in no small degree was the success due to his efforts. Prof. Campion, in reply, thanked the members for the tangible token of their esteem, and remarked that he had already been amply rewarded for any services he had rendered by the appreciation of the members. His business was to further the interest of metallurgy, and as one of the aims of the association was to encourage the study of this subject, he could not do otherwise than give the association his support.

**INVAR.**—A very valuable alloy of nickel and iron is that known as Invar, which contains about 36 per cent. of nickel. It has been found that the coefficient of linear expansion is decreased by the addition of nickel, and becomes almost zero at about 36 per cent. Ni. The alloy is found extremely useful in accurate measuring instruments, and for a variety of purposes requiring a metal of invariable dimensions under varying atmospheric temperatures.

# Unorthodox Patterns.*

By J. R. Moorhouse.

It is admitted there should be no excuse for an unworkable pattern, but there are occasions when conditions positively compel the patternmaker to pass on to the foundry patterns that are scarcely worth the name. These add considerably to the foundry costs, and result in unsatisfactory castings—a very questionable economy. But apart from these, a pattern may be quite practicable and leave much for the moulder to do to complete his mould. Of such nature are the "one-off" variety of patterns; and just where the line should be drawn in regard to what should be done in the pattern-shop and what left for the foundry to do, in view of the entire cost, is of itself a controversial subject. When patterns are required for standard work too much consideration cannot be given to saving labour in the foundry. Such patterns should be built up in the best possible manner for repetition moulding.

It is here where the patternmaker is often in a difficulty. Though expense may be no consideration time is vital to the making of a reliable and efficient pattern. As ideas are perfected and laid out in the drawing office there is a rush to get these going in the pattern-shop, so that some tangible result may be seen in the shops as soon as possible. The daily reminder and inquiry, how soon these are to be sent on to the foundry, is no encouragement to thoroughness, neither is it conducive to the best of relations between the foundry and pattern-shop.

Given adequate and up-to-date machinery, arranged to the best of advantage in a well-lighted and ventilated building, the most vital factor in getting out good work and workable patterns cheaply and quickly is ensured. Of a secondary consideration in the make-up of a pattern is the materials used; and although timber will remain the standard for most classes of work, against which no other material can possibly compete, there are occasions when plaster-of-Paris can profitably be used for the quick production of patterns, not for the saving in the price of the material, but rather because it so readily can be worked up into intricate shapes that otherwise would require considerable labour if worked out in timber.

To the wood patternmaker this necessitates what, to him, are unorthodox methods of procedure in pattern construction. The use of plaster-of-Paris in the pattern-shop, as is well known, is not new; the writer in his early apprenticeship worked plaster for patterns. It was then used for making accurate forging-tool patterns, one example being a railway carriage draw-bar hook. A model of the hook to be forged is first made in halves in wood. This is then passed by the inspector to check all sections, etc. A frame is now made to conform to the dimensions of the forge block required, and deep enough to leave ½ in. of plaster at the shallow portion covering the hook face; nails are then driven in the inside with the heads protruding well out, to form an anchor for the plaster. One half of the hook, which has previously been varnished and thinly smeared with oil, or preferably vaseline, is secured to a board, on which is now placed the frame, over and in correct relation to the hook. Having made this secure, the plaster is run in and strickled flush with the frame edges. In a few moments the board can be inverted and the hook carefully withdrawn, leaving a perfect impression of the hook in the plaster pattern. It needs no argument to show how much quicker this can be accomplished than working the hook by trial and error into a wood block. To form the top stamping block the process is very much the same, with the exception that the two halves of the hook are placed together as a means of registering the top in true relation to the bottom, so that the stampings will not be overshot, and put back in the already half-formed plaster pattern, on which is fixed the mating frame for retaining the plaster forming the top half block. This is weighted and then run in with plaster. When set it can be carefully removed, leaving a true impression of the model. The same procedure is often followed in jobbing lines of valves and intricate inlet pipes, etc.

A little experience is necessary, especially on strickle work to manipulate the plaster to the best advantage, as when once it commences to set it cannot be restored without seriously impairing the strength of the pattern. The amount of plaster to use to a given quantity of water varies according to the nature and grade of the material, as also the temperature of the room in which plaster patterns are to be made. A good method is to lightly and quickly sprinkle the plaster over the whole surface of the water, until it begins to settle on the surface. This is then thoroughly mixed, preferably with the hand, until it has a creamy nature, when it can be then run off. For strickle work it may be necessary for the first coat to run it a trifle stiffer, and thinner on the finishing layer. These, however, should follow immediately, if possible one on the other, to form a bond for the best results. Especially is this necessary on thin strickled sections, where it is found impossible to complete it at one operation.

It should be mentioned here that a useful material for working along with plaster-of-Paris, and which widens the field of application for pattern construction, is plasticine, a class of modelling clay. With this material, holes or pockets can be readily formed in plaster moulds, in the same way as cores are used in the sand mould.

To illustrate this may be taken the example shown in Fig. 1, a segment of a grided type of casing. From a study of the plan *A* and section *B*, it was decided to have a metal pattern and bed in the floor. To make the master pattern in wood, to leave its own cores, would not only be most expensive but very unsatisfactory, due to it being so fragile and difficult to keep from warping. The method here shown for making a plaster-of-Paris pattern was successfully used, at a great saving in time and labour.

A bottom board, *C*, is first made large enough to cover the size of flask for moulding the master pattern. This should be fairly strong and the joints left open, on 9 in. width of stock. This is to avoid any winding of the pattern that otherwise might result from the wet nature of the material to be worked on it, followed by the heat of the foundry. An approximate position is then laid out on the board, setting the pattern to the best advantage

* Paper read before the Lancashire Branch of the British Foundrymen's Association, February 5, Mr. H. Sherburn in the chair.

for the moulder. On this is built up a latticed structure (as shown at *C* and *D*) with timber of a rough nature, to form a foundation for the sweeping of the plaster. A reference to the section *D*, and the plan *C*, will help in showing the necessity of forming a base, not only as a support for the pattern proper, but also as a means to developing the inside shapes, and forming the mould joints to the pattern.

It will be seen that the strickle *F* is cut to the inside shape and centred by means of a pin in a temporary wood strut at the right-hand corner of the bottom board, not shown in the illustration. On this it is free to rotate, and is first used as a template to locate the positions of the bearers, on which are nailed rough-cut laths, to leave not less than ¼ in. thickness of plaster-of-Paris in the thinnest part. The bearers are screwed down on the bottom board, and the laths left ½ in. apart so as to form a bond for securing the plaster in position.

It follows that the framework and the bottom board is practically in one piece and may be rolled over without any fear of displacement. This method of construction is to be preferred, if only for this very reason, to the use of coke, so often used for filling in the body work of plaster supports. It is also more economical as regards the quantity of plaster used.

A detail that should be noticed is the correct setting and jointing down to the pattern, to avoid any cutting or trimming of the mould. Also the lift forming the cope part should have ample taper and a margin not less than 1 in. from the pattern be allowed to form a bearing to assist the sand in the cope. A rather stiff layer of plaster is now spread over the laths, for filling in the spaces between them, or otherwise the plaster would run to waste. This first layer, if not immediately followed by the second coat, should be left rugged and kept ¼ in. clear of the sweep.

This is to insure the second and final layer of plaster being thick enough to resist the rapping from the mould without breakage. If it is possible, as was the case in this instance, to combine the first and second layer together before the first layer is set a more permanent job is assured.

In sweeping the support the strickle is operated in a way similar to that for loam, the bevelled edge being the leading side of the board. The plaster is run on from the top and, falling down the side, is strickled off, to be returned back for filling in any shortage, this operation being repeated until the inner support is complete. Needless to say, this operation cannot be delayed, and the quicker it is got through the better. A good finish to the surface is obtained by repeated washing of the strickle in the final strokes to prevent the hardened plaster from cutting.

The bottom board is now cleaned of all waste plaster, the ends squared to length and the support given a coat of varnish. It is now required to make the pattern proper, as shown by the black outline at D. The sweep, *F*, is cut back to the metal thickness, shown outlined on the sweep, and a layer of plasticine laid over the support to determine the correct length of the pattern on the angle. The centres for the openings of the grids cutting through the pattern are also laid out, to which centres are fixed plasticine cores rolled out to the required thickness in the frame *E*. These are made a trifle less in thickness than the metal thickness, so as not to foul the strickle when sweeping the pattern. This method of cutting through the plaster saves a lot of labour, as the plasticine can readily be bent into shape and secured in position with sprigs.

These cores having been fixed on the support, previously greased, the strickle *F* is put in position and the plaster run on in a manner similar to that de-

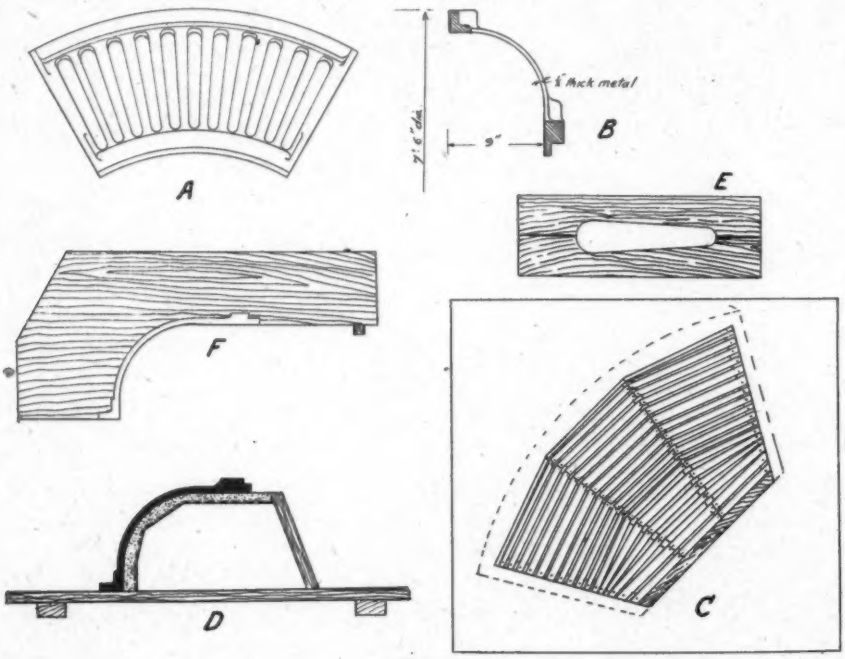



FIG. 1.

scribed for the inner section. Work of this nature should be done in a warm, dry room, to encourage the hardening of the plaster. No attempt should be made to remove the pattern until it is thoroughly dry and hard. The plasticine cores are then removed and the edges forming the openings rounded off. A few gentle taps on the bottom board will free the pattern, when it can be removed and finally trimmed and varnished. The wood snugs are fixed in position with shellac varnish.

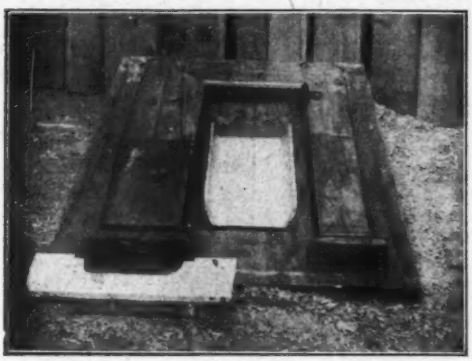


FIG. 2.

and drawing the pattern remains in principle the same as in general practice.

It is understood that extreme care is required on the part of the moulder in handling patterns of this nature, and an instance that testifies to the care that can be taken with patterns of this kind is that of a plaster pattern, covering 12 sq. ft. of ¼ in. thick sections, that was in the same condition at the finish of four castings as at the commencement. It is not here meant to suggest that plaster be used for anything apart from the one-off variety, though the temptation is to exceed it, as in the case above mentioned. In large patterns it is advisable to keep the plaster sections small enough to be conveniently handled, and for the purpose of easy withdrawal from the sand. An example illustrating this is shown in Fig. 2. The principle of constructing the inner supporting sections is the same as described for the grid segment casing, with the exception that they are built up separately on a strike board, the bottom board being used for assembling the sections together and keeping them in position for moulding purposes only.

It will be noticed that there are two sides and one end piece forming a large *U* channel section, a part of which is shown removed and in the centre. On the bottom board is laid out the correct length and mitres, which are transferred to a strike board for the purpose of sweeping up the inner sections. This board is made a trifle wider than the width of the pattern, so as to serve as a guide for the sweep

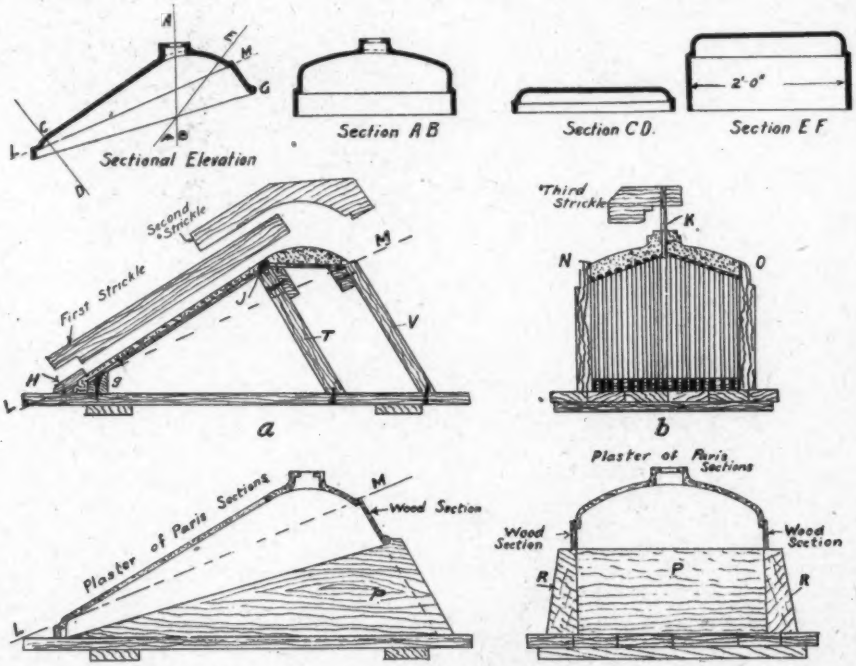



FIG. 3.

The procedure of moulding patterns of this description is the same as making a mould from a pattern of a oddside, or jointing-down board. The drag part is first put in position over the pattern on the bottom board, rammed up and turned over. The bottom board, in one with the support, is then withdrawn, leaving the plaster pattern in the sand. The cope is fixed and the procedure of ramming shown in the bottom left-hand corner. Bearers are now screwed down temporarily in their positions, as set by the strickle, to leave ¼ in. of plaster above the laths. There is no difficulty in completing these inner sections at one operation, as they are straight and narrow and lend themselves to quick manipulation of the strickle. As each part is complete it is removed for varnishing, and each in turn placed

back on the strike board in the original position to have the pattern formed on them. The same strickle as used previously is made applicable for

FIG. 4.

these by cutting back the metal thickness and being similarly guided on the strike board.

It will be noticed that the pattern is in twelve sections. The first section is run up to temporary wood strips, limiting its size. The strips are then removed and the others run up to the already finished section. Having completed the parts, the inner sections are finally assembled on the lay-out on the bottom board and screwed in position, so forming a means of keeping the pattern sections in place during the ramming of the mould.

An example of a casing is shown in Fig. 3, where the straight, loose sections are made in wood, plaster being used only for the curved portions. From the sectional elevation, and sections through *A B*, *C D*, *E F*, it will be seen that to make a pattern in wood and a core-box to register an even ¼ in. of metal would necessitate the handling of many templates and require quite a time to complete. As in previous examples, this is for the purpose of obtaining a metal pattern only.

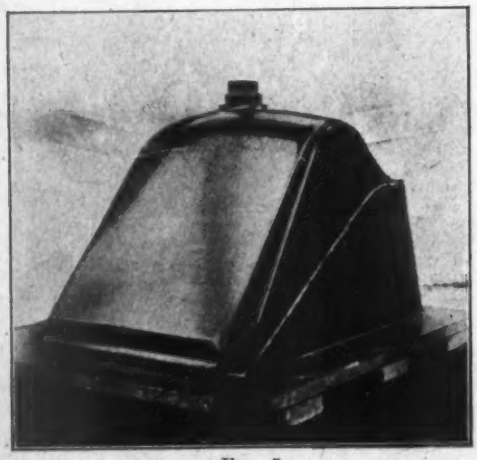


FIG. 5.

Referring to the sections, at *C D* it is straight, with the corner well rounded off. This tapers up into a curve at *A B*, and falls back into the straight again at *E F*, remaining the same section to the point *G*. The preliminary construction will be understood from the side and end elevation, *a* and *b*. It is, of course, necessary to have previously laid out the arrangement so that all particulars and sizes can readily be obtained, as also to fix the height of the point *G* from the bottom board to allow for the nozzle to lift square in the cope. From *a* the principle of sweeping over the plaster will be clearly seen. A former piece, *H*, is shaped to the correct outline forming the part of the casing resting on the bottom board. This also serves as a guide for the strickle working at this end. At *J* is fixed a segment to the required radius at this particular position, on the already fixed laths, and on this is worked the strickle in a parallel line with the centre line of the bottom board. The side pieces, *N*, *O*, at *b* will be seen to come well above the plaster and serve to retain it in position during the strickling operation. These are finished to the correct inside size, with the steps cut in them along the line *L M*.

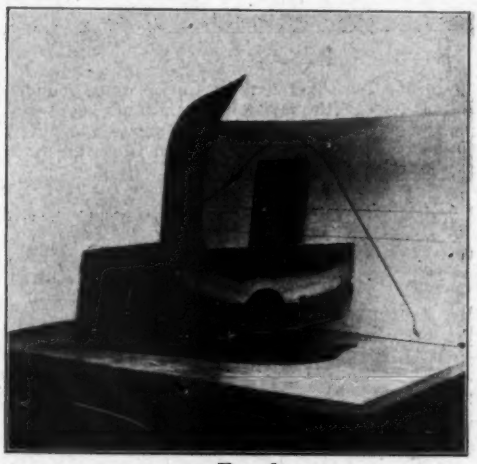


FIG. 6.

To run the plaster, the board is tilted, to bring the support as level as is practicable. The plaster is then run on and strickled in the manner previously described. The corners are shaped afterwards, as at *O*, in the wood to fair into the plaster section. It now remains to finish the crown with the second strickle, which is made to slide on the straight at *M* and on the curved guide *J*, the straight part being set on the angle *L M*, to insure no interference when strickling.

This will now complete the support with the exception of the nozzle, it being noted that the bearer *J* is not removed, but left in position to serve as a location line for the pattern proper. To form the nozzle, its position is accurately located and a hole bored in the plaster for a pin, *K*, to have a fairly tight fit, on which is worked a strickle in the manner shown, a few sprigs being first stuck into the crown to assist the plaster in keeping its position; the plaster is run on and completed. The support is now finally cleaned from all waste, the mould piece, *H*, removed and the support given a coat of varnish.

To form the pattern three sections are made in plaster for the curved portions above the line *L M*, and three sections in wood, for the straight parts forming the sides and end. Each of these is ¼ in. in thickness. The plaster sections

are jointed along the lines *L M* and up the centre line of the casing for the plaster sections.

The procedure of forming the pattern is very much the same as already described for the support. A mould piece for the section *C D* is shaped to the desired contour of the casing and forms the straight guide for the stepped end of the strickle. This is screwed on to the bottom board to leave ¼ in. of plaster. A curved bearer for the top of the strickle to work on is temporarily fixed on the curved strip *J*. For the purpose of confining the plaster to the first section, a wood strip is fixed along the centre line to the top guide *J*. Also a piece of wood is screwed temporarily to the side to retain the plaster at the corners. This section is then run off and worked by the strickle on the bearers, so fixing the shape and thickness in keeping with the support.

As soon as this is set the strip along the centre is removed and the next section run on the reverse side in a similar manner. To form the crown piece, the second and third strickle are worked in combination so that the nozzle may be formed in one piece. It will be noted that the range of the second strickle is limited to work between the

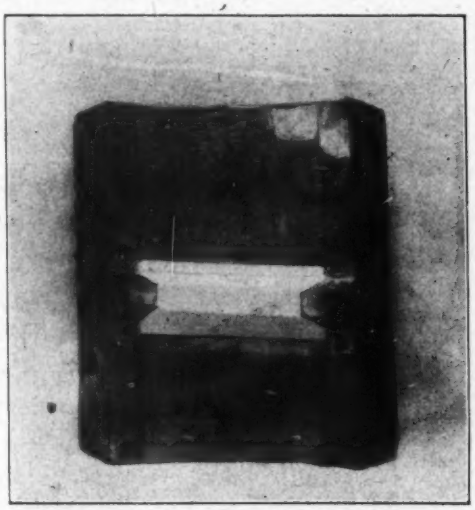


Fig. 7.

nozzle and the side piece, which retains the plaster at the corners. This short difference is worked with the gauge to template and faired into the radius at the root of the nozzle. The strickle forming the crown is operated on the edge of the completed sections, and in this way ensures correct alignment. Referring to the elevations *a* and *b*, the straight wood sections will be clearly understood, as also the jointing up to the pattern proper.

Fig. 4 shows the support completed, with one section of the pattern in position and the bottom guide piece removed. Fig. 5 shows the completed sections in position and complete; and in Fig. 6 all the sections are seen removed, with the lay-out in the background.

In the February issue of THE FOUNDRY TRADE JOURNAL was given a method of developing worm threads and worm-wheel teeth at a fraction of the cost of wood patterns. Reference may be made to that article in order to clearly show further development of that work. The article in question described a worm struck up in plaster between the centres of the lathe, by means of a strickle cut to the thread sections, and given a lateral movement by means of a spiral groove cut in the wood centre, in which engages a hard wood projection on the strickle.

It may be repeated here that in contrast to a worm-thread a worm-wheel tooth is not a uniform section, as is generally assumed; the greater the lead and the less the number of teeth, the greater

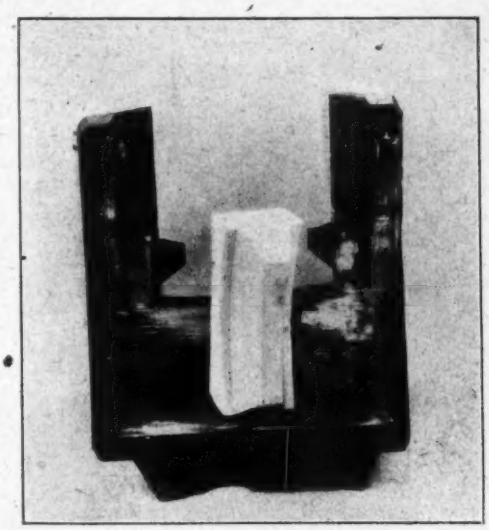


Fig. 8.

this difference; and it is only by hobbing the pattern or pattern tooth block into the worm that accurate results can be obtained.

In the article previously mentioned was shown how a plaster block is first struck up in the lathe, at the end of the worm pattern, only with a tooth section in place of a thread section, and guided by the spirial previously referred to. This was shown cut off and a jig fitted to give the outside shape

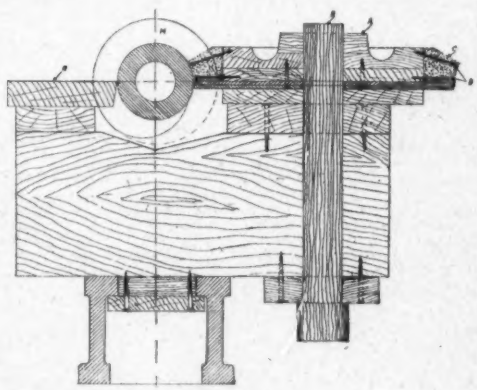


Fig. 9.

of the tooth. Fig. 7 shows the jig removed with the tooth in position. Fig. 8 shows the tooth removed from the jig. These teeth can be readily fixed to a wood centre by first shellac varnishing the parts coming together, allowing them to thoroughly dry, then re-varnishing when fixing in position.

C

For wheels of single threads, and of a large number of teeth, this method is sufficiently accurate for cast working gears; also for treble threads with few teeth when the wheel is to be cut, in which case the object is simply to relieve the teeth of a large amount of machining. For cast working gears an error is shown by this method, but overcome by the tooth mould on the table, which in principle remains the same, though in place of a straight worm it is made to the curve representing the wheel diameter.

These teeth are similar to teeth cut with rotary cutters at the correct angle, and to be quite accurate

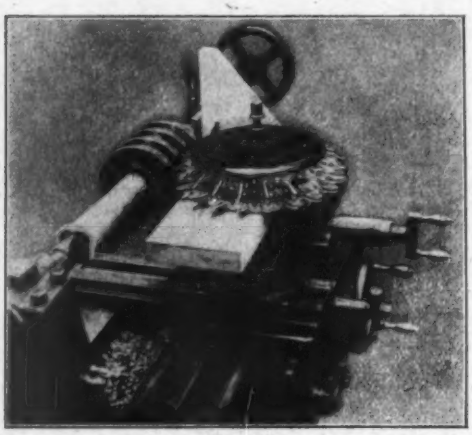


FIG. 10.

should be hobbed. It was during the making of these plaster teeth that it occurred to the writer that it might be possible to run plaster up to a worm in motion so as to get strictly accurate results. This was done on the same principle as the hobbing of a worm, with this difference, that with the hobbing machine the worm hob removed material, and with the process to be described, material was placed and formed up to the worm as the hob. Fig. 9 illustrates this better. A built-up block, *A*, is made in wood segments to form a base, around which is to be fixed the plaster-of-Paris, *C*. To give motion to this block, a piece of three-ply timber is cut as accurately as possible to the required shape and number of teeth. This is made to work into the worm *M*, and hard up to the roots of the thread. It is additionally strengthened with another piece of three-ply immediately underneath it. These are then screwed into the centre, as shown, and made to work on a pin securely fixed either on the rest or on a structure similarly fixed to the lathe bed as shown. It will be evident that the worm being placed between the lathe centres and made to revolve will also cause the wood centre to rotate round the pin *B* in a manner similar to the complete worm drive.

It should be noted in forming this half-pattern that the three-ply timber is kept on the centre line of the lathe centres. To keep the plaster in position large-headed nails are driven into the centre block, as shown at *D*. These are further augmented with sprigs to assist in retaining the plaster at the roots of the worm teeth. In running on the plaster it has the same inclination to stick to the worm as it has on the worm wheel, and to overcome this a board cut to the worm threads sections is made to serve as a cleaner, throwing off any plaster that may stick on the worm. This is shown at *N*, sliding on the support,

At Fig 10 everything is shown in readiness for the running of the plaster. It will be observed that the wood platform in this instance is unnecessary, the lathe tool post answering admirably for the pin around which the wood centre is to revolve. Those who have had the experience of making a worm-wheel pattern of, say, 30 teeth, and the monotonous method of hobbing to a worm, when told that this half-pattern will be completed in five minutes and be a far more accurate job, will no doubt allow that a saving is certainly effected over the five days that would be required. No doubt those having worm-wheel patterns to make continually would do well to study this method for wheels up to 30 teeth and 2½ pitch. Beyond these sizes it would be advisable to consider the aforementioned method, as described in the February issue of THE FOUNDRY TRADE JOURNAL. Those not accustomed to working plaster-of-Paris will need a little experience and attention to the nature of it before attempting to make a worm-wheel pattern. It is necessary, to make a successful pattern, that the plaster be placed as quickly as possible and the lathe stopped before the plaster has thoroughly set.

In putting forward these examples the writer wishes it to be distinctly understood that he speaks entirely from a pattern-maker's standpoint. It is admitted that extra care is necessary on the part of foundry if plaster patterns are to be a success.

### Discussion.

MR. PENLINGTON said it was a very delicate question as to where the line should be drawn between making the wood patterns and plaster patterns. That applied to pattern-making generally, because in the engineer's shops, and in shops concerned chiefly in repairing work, it was a matter of expediency, when they had to send men out to get particulars, that certain timber should be prepared meanwhile, so that the pattern might be put together as quickly

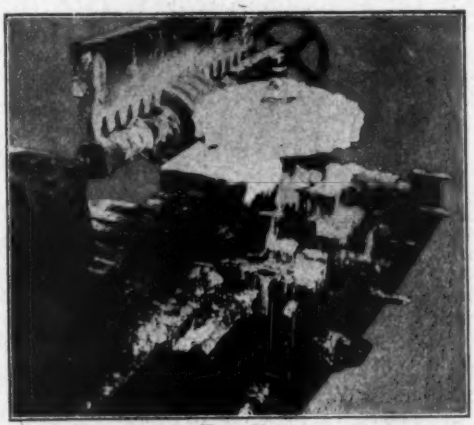


FIG. 11.

as possible. Pattern makers were generally admitted to be a necessary evil from the employers' point of view, because the pattern as a rule simply went back into the pattern shop, while the product was sent out and cash obtained for it. The plaster pattern had latterly come more and more into vogue in the heavier class of work. The author had shown what could be done by moulders when they had patterns before them and would take proper care. The education of the moulders had brought plaster patterns into greater vogue in the shops. With re-

gard to worm and worm wheels, those were patterns which lent themselves to plaster work, and proved a considerable saving in time. The question was, however, a matter of debate still, for they knew that some people were apt to rush away with the idea that everything should be made in plaster; but it was necessary to draw the line in certain cases. Much more care was needed in using the plaster pattern than the wood pattern, and it was necessary to guard against adopting the former simply for the purpose of cheapening the cost of pattern-making in the shop. The result as a whole should be considered. The author had referred to the pattern in Fig. 10 being made in five minutes, but that was simply incredible, and the average cost as given was also incredible. He knew that in Yorkshire patterns were made very quickly and cheaply in various ways, but as a fact very few shops would be able to make patterns of that description, for it seemed they had to go down into the machine shop to do it, where it would take perhaps 20 hours. Then, again, a man who took a pride in his machine would not like to see it covered all over with plaster, and though a man might be set to clean it, the machine man would probably take another hour himself to finish the cleaning. Plaster was cheap no doubt, but it must be used with discretion.

**Mr. Simkiss** said the cost of patterns was certainly a question of great importance to all foundrymen. They had to deal with patterns made of all kinds of material, and plaster was not the least, or even the latest. Considerable time, he agreed, was saved in making plaster patterns, but he did not think it was quite fair to the foundry that the whole of the saving should be credited to the pattern shop. He ventured to say that 75 per cent. of time was saved in making with plaster, but when it got to the foundry it easily tacked on 125 per cent. to the time. If a firm made something out of the saving of time, he was afraid they would have to hand a portion of it over to the foundry. With reference to the point made of the peculiarity of the position of pattern-makers in making patterns for the foundry, he would like to remark that foundries were adapted for doing a particular class of work; if they received a pattern, or were put upon work they were not used to doing, then the pattern was certain not to be right. If, again, it was sent to a foundry where they were accustomed to that particular kind of work, the result might be very satisfactory, but if it were sent to one where they were not used to it, the job would not be satisfactory. It would have been interesting if Mr. Moorhouse could have given some wrinkles with regard to the various qualities of plaster, of which, he believed, there were three, and the methods for hardening and for keeping it in liquid state for intricate work, for making joints and so on. He would like to ask if a plaster-made wheel, such as the one then on the table, would be truer than a wheel taken from a wood block pattern? Then, perhaps, Mr. Moorhouse would state what he used in the way of greases.

**Mr. Bickerton** remarked that as a foundry foreman, he would not like to take upon himself the job of working to plaster patterns at so much a cwt. He would prefer to take them by time. To work off them systematically, he thought the foundry foreman would lose all that the patterns saved.

**Mr. Moorhouse**, in acknowledging a hearty vote of thanks which was accorded to him, said that five minutes was the time occupied in putting the block in, and the plaster would set in a few minutes. In the case of a wheel of the description of the one lying on the table, it was only necessary to make one-half at once; the other half was simply a duplicate. Arrangements for pattern making had to be adapted to circumstances and to the particular work required. The machine cleaning, to which Mr. Penlington had referred, could be done in less than half an hour. He intended to have brought before them the necessity of having up-to-date machinery for the purpose. The positions of Mr. Simkiss and himself differed; he was concerned with the making of patterns, while Mr. Simkiss was concerned with the making of castings. He thought there should be some acknowledgment in some way of the saving of time in the pattern shop by the method he had been describing. With respect to the quality of the plaster, he always used the finest that could be got.

## Pig-iron Output in 1915.

We have received from the Iron, Steel and Allied Trades Federation Statistical Bureau, at 28, Victoria Street, S.W., statistics of the production of pig-iron in the United Kingdom in 1915. The totals of the different descriptions are as follows:—

| | 1914. Tons. | 1915. Tons. |
|---|---|---|
| Forge ... ... ... ... | 3,490,448 | 1,024,063 |
| Foundry ... ... ... ... | | 1,573,575 |
| Basic ... ... ... ... | 2,003,693 | 2,272,684 |
| Hematite ... ... ... ... | 3,235,403 | 3,564,276 |
| Spiegel, ferro-manganese, ferro-silicon etc. ... ... ... | 336,354 | 255,484 |
| Direct castings ... ... ... | — | 103,577 |
| | 9,005,898 | 8,793,659 |

The 1914 figures above given are those collected by the British Iron Trade Association. The total for 1915 includes an estimated amount of 53,000 tons. The production last year by districts was as follows:—

| | No. of Furnaces. | | Forge. | Foundry. | Basic. | Hematite. |
|---|---|---|---|---|---|---|
| | Built. | In Blast. | Tons. | Tons. | Tons. | Tons. |
| Durham & Yorks. | | | | | | |
| Cleveland ... | | | 213,610 | 624,319 | 839,929 | 687,223 |
| Durham ... | 135 | 79½ | 6,162 | 6,665 | 54,616 | 460,101 |
| S. & W. Yorks | | | 35,406 | 40,070 | 209,181 | |
| Cumberland. | | | | | | 574,499 |
| Lancashire & N. Wales. | 74 | 33½ | 13,043 | 16,074 | 226,874 | 366,925 |
| Scotland. | 102 | 71½ | 74,974 | 318,920 | | 710,486 |
| Midlands (Derby, Leicester, Northants. and Notts.) | 72 | 43 | 366,947 | 402,905 | 22,883 | |
| Lincolnshire. | 20 | 16 | 52,748 | 16,042 | 485,225 | |
| S. Wales & Mon. | 26 | 12½ | 1,034 | 1,927 | 61,528 | 765,042 |
| N. Staffs. & Salop | 27 | 16 | 125,621 | 58,037 | 161,362 | |
| S. Staffs., Worcs. & Wilts. | 33 | 19½ | 134,518 | 88,670 | 211,086 | |
| | 489* | 291½ | 1,024,063 | 1,573,575 | 2,272,684 | 3,564,276 |

* This total of "Blast Furnaces Built" includes one furnace in course of erection.

**CASTING OXIDES.** — According to a process patented by the Soc. Italiana di Elettrochimica, Rome, castings of high chemical and mechanical resistance are yielded by iron oxides alone or mixed with isomorphous oxides, when the composition is such that the ratio $M_2O_3$ : MO exceeds 3 (M = metal). The structure of the product is finer as the composition approaches $M_2O_3$. This state of oxidation is obtained by oxidising the melted oxides with oxygen (or air) under pressure, or by treating the mass with oxygen-carrying agents and strongly stirring the melted mass. The charge, which may consist of metallic iron, burnt pyrites or other iron oxides, even of moderate purity, is melted in a closed electric furnace and at once oxidised, or the oxidisation may be carried out in a species of converter. The operation must be carried out quickly so as to prevent the solidification of the mass, which is stated to become pasty towards 1,350 degrees Cent., and the castings must be made while the oxidising gas is being injected.

# Carbon and Iron.

At a meeting of the Birmingham Branch of the British Foundrymen's Association on March 11, Professor T. Turner, M.Sc., A.R.S.M., of Birmingham University, lectured on "Carbon and Iron." Mr. J. Shaw (Vice-President) occupied the chair.

Professor Turner said that it might be a convenient division to classify the subject into three parts, namely, (1) The ascertained facts, (2) the theoretical explanations, and (3) the practical application of the ascertained knowledge to the ironfounder. With regard to the ascertained facts, the different properties found in mild steel, in medium hard steel, in hard steel, in white iron, and in soft grey cast iron, depended primarily upon the proportion of carbon present and the condition in which it occurred. The steels and the cast irons formed a continuous series beginning with pure iron, or iron containing no carbon, and extending upward to iron fully saturated with carbon, i.e., containing the maximum of 6.8 per cent. carbon, which was iron carbide. Foundrymen had been rather in the habit of looking at this series from the point of view of cast iron and regarding steel as of comparatively little importance. But it was more important that the foundryman should know the properties and constitution of steel than it was for the steelmaker to know the properties and constitution of cast iron. They might consider that in all cast iron there was a certain proportion of what might be called steel base. It might be a very mild steel, or the cast iron might be more or less of the character of a hard steel. The ordinary steelmaker was practically not interested in the higher carbon cast irons. Iron had been shown to exist in several forms, in the same way as sulphur or carbon or phosphorus and other elements were known to exist in allotropic modifications. There had been a great deal of discussion in connection with what was called the allotropic theory of iron, which was first introduced by Osmond and supported by Roberts-Austen. The theory was largely based upon the fact that in pure iron there were two arrests in the rate of cooling, one at about 900 deg. C. and the other at 760 deg. C. It was suggested that above 900 deg. C. iron existed in the hard or Gamma form and below 760 deg. C. in the Alpha or soft form. Between 760 deg. C. and 900 deg. C. there was an intermediate or Beta variety. That theory had been called in question quite recently at a meeting of the Faraday Society by Mr. A. E. Oxley, who stated that the changes in iron were more nearly allied to physical changes than to true allotropic changes. At a meeting of the Iron and Steel Institute, held two years ago, there was considerable elation over what was called the "death and burial of poor Beta." But Beta had been resurrected again, since that meeting, and as he had ventured to say elsewhere, whether Beta ought to be regarded as a distinct allotropic variety, or merely a physical modification, there was no doubt a certain range of temperature at which iron possessed certain characteristic properties, and those properties were associated with the term Beta iron. Whether the change was physical or allotropic was not a matter of practical importance; the importance lay in the difference of properties.

One objection raised to the allotropic theory was that there was a relatively small evolution of heat at the first arrest at 900 deg. C. on cooling, and the evolution was still smaller at the lower point 760 deg. C. If the iron was perfectly pure, there was no special change after that stage. Professor Arnold had made careful tests with the purest material, and considered that at or near 760 deg. C. a change took place which was shown by two small points. It had been suggested by Benedicks that the Beta was a sort of overlapping of Alpha with Gamma. If that view were correct, the lower arrest should disappear altogether on a rising temperature. That led to considerable discussion at the Iron and Steel Institute, which followed two lines. It was suggested by one class of speakers that the arrest $Ac_2$ consisted of two points close together, and not a single point; while a second suggestion was that in perfectly pure iron there was no arrest at all. Other experiments had since been made, with 130 samples, by the American Bureau of Standards who dealt with the matter with the greatest possible delicacy. In every case they found that the arrest point $Ac_2$ was present, and that it really was a single point and not two. It had since been tested in the laboratory of the Sheffield University by Mr. F. C. Thompson, and the results were presented before the Faraday Society quite recently. It was shown that $Ac_2$ was a definite arrest point, occurring at 765 deg. C. It had been extremely difficult to ascertain the properties of pure iron, because even in the case of dead-mild steel it was found that the heating of the metal for a time in vacuum made some difference. There were minute quantities of impurity which tended to show themselves. As the carbon increased, the iron became more fusible, and the $A_3$ point of arrest would occur at a lower temperature, until at about 700 deg. C. and 0.9 per cent. of carbon there was a single point. The difference in properties observed in varieties of iron and steel were due chiefly to the variations in the proportion, and in the state of combination, of the carbon present.

The equilibrium diagram was not theoretical, but was the record of the result of careful experiments, and gave in a convenient and brief form the knowledge resulting from all the observations that had been made.

It was only 150 years ago that it was shown by Bergman that carbon was the distinct and decisive element in steel, and it was as recently as 1885 that carbide of iron was first isolated by Abel. The important developments were all modern. There was the work of Chatélier in connection with the pyrometer, Sorby with the microscope, Bessemer in introducing his steel process, Siemens the open-hearth process, and Thomas and Gilchrist the later developments of the basic system. Incidentally that showed that the most important developments had all come from this country, although the French and Swedes had rendered important assistance. Others had developed bigger works and larger output, but the great epoch-making discoveries which would affect and benefit the world for all time were those he had mentioned.

The amount of carbon absorbed by iron was determined by the temperature employed, and the higher the temperature the more carbon would be absorbed. Below 700 deg. C. iron did not dissolve carbon. At 900 deg. C. it dissolved appreciably, and the solubility increased with the rise of the temperature.

From the foundryman's point of view the maximum carbon would be 4.5. But it was possible to introduce much larger quantities, and when 3,000 deg. C. was reached, which was quite possible with

the electric furnace, as much as 20 per cent. carbon might be present. Manganese and chromium had the effect of increasing the solubility of carbon, while silicon and aluminium had a contrary effect. With regard to its method of introduction, it was now usually agreed that it went in in the form of carbide ($Fe_3C$.); but the contrary seemed to be proved by some experiments made some years ago by Royston, which appeared to suggest that it might diffuse elementally. Adams, however, made further experiments showing that those by Royston were inconclusive.

Professor Turner went into some detail in the description of these experiments, the general conclusion of which were that carbide might (1) exist in solid solution in iron: (2) separate as carbide (cementite), (3) form part of a eutectic: (4) decompose with separation of graphite, either primary or secondary. At the lower limit of the temperature of the solidus (1,130 deg. C.) there might be a solid solution of carbon in iron up to 2 per cent. Then there might be a mixture of eutectic and solid solution carrying carbon from 2 to 4.3 per cent. That was the ordinary cast iron which mostly interested foundrymen. Next there was the eutectic, then a mixture of carbide and eutectic, and finally carbide. There were thus five structures, three of which might be regarded as separate phases by the physicist, while the other two were merely characteristic mixtures of the phases. From the foundryman's point of view, first, there was steel, which included all the Austenite properties. Then there was the hypoeutectic cast iron representing the Austenite and the eutectic, with less than 4.3 per cent. Taking the cast iron they had to deal with, it was found that the Austenite might decompose at 700 deg. C. in part, and throw out some of the pearlite or decompose completely and leave only the silicon with the iron.

The hardness and tensile strength of cast iron ultimately depended upon (1) the proportion of carbon and other elements retained in solution by the iron, e.g., cementite, silico-ferrite, and (2) the proportion, size and arrangement of the bodies thrown out of solutions, e.g., graphite, iron, carbon, phosphide eutectic, etc. It was possible to make the ground mass, or steely part, of cast iron of the strength desired by securing the right proportion of carbon, and by adding other elements such as chromium or nickel. A great deal of care and research was required to ascertain the maximum points of usefulness in the employment of these alloys.

Calling attention to another diagram, illustrating the influence of elements in solid solution in iron, Professor Turner pointed out that some of these curves had not yet been worked out and further research was wanted. A series of views was exhibited showing the structures of cold-blast cast iron, Cleveland iron, and the effect upon the crystalline structure of the increase of carbon up to 3 per cent. The lecturer remarked that silicon had the effect of throwing carbon out of solution. Metal in which the graphite was coarse would be weak, but where the graphite was fine the metal would be strong. In strong Swedish iron there was just sufficient silicon to throw out the graphite.

### Discussion.

The CHAIRMAN referred to a Paper given by Mr. J. E. Johnson* on the subject of introducing oxygen into cast iron. According to that author, the presence of oxygen produced excellent results, and he rather inferred that some of the strength of Swedish iron was due to oxygen. Other experiments dealt with cast iron which was Bessemerised, and a certain amount of oxygen introduced, reducing the carbon at the same time. Johnson claimed to have produced in that way some exceptionally strong iron. He would also like Professor Turner's opinion on what Mr. Adamson had said in reference to free graphite.†

MR. R. BUCHANAN said that he was greatly interested in the remark with reference to the allotropic modifications in pure iron. He had been puzzling for some considerable time as to the reasons why iron of similar chemical composition should exhibit very dissimilar physical characteristics. He remembered being told by Dr. Swinden of an experience with a Swedish blast furnace. It was found that by increasing the volume of blast they altered the physical characteristics of the iron without altering the percentage of the constituents, and could secure an increased output. But the iron was weak as compared with what was obtained with normal blast. He would be glad to hear from Professor Turner whether he considered the difference in physical strength arose from some modification of the iron itself as distinct from the other elements present, or to what he would attribute the differences he had mentioned. He was also interested to hear the explanation given of carbide of iron, and its diffusion from one steel or iron to another having a different carbon content.

MR. F. J. COOK said that he quite agreed that carbon was the ruling element determining the physical properties of the metal. The physical properties of cast iron would mainly depend upon the quantity and the condition of the carbon. The diffusion of the carbon from one sample to another in the presence of gases furnished an explanation of what took place in the making of so-called semi-steel. Some years ago he noticed that in such cases the carbon was not decreased. He had himself produced semi-steels containing up to 40 per cent. of steel in the cupola, and the remarkable fact was that there was no difference in the carbon contents of ordinary cast iron made from pig-iron alone and that with 40 per cent. steel. With reference to the curves showing the relation between tensile strength and hardness, he had set out curves from his own practical work which bore out what the lecturer had said, that as the hardness increased so did the tensile strength up to a point, and then fell away again. The same conclusion was borne out by some experiments he made with blast pressure in the cupola. As the blast was increased, so was the hardness. With regard to the formation of the eutectic, Professor Turner emphasised the fact that the strength of cast iron not only depended upon the quantity of carbon and other elements, but on the way in which they were associated. He would be very glad if the lecturer could give them an idea of the way to produce the small graphite which had so much to do with the production of strong iron. It was quite possible to have similar and identical analyses with very substantial differences in physcial properties.

MR. I. I. HOWELL said the lecturer had stated that the carbon existed in the iron in the form of iron carbide. That was so when the iron contained less than 2 per cent. total carbon. But he believed free carbon must be present when there was 3.5 per cent. carbon in the iron. The pearlite

* "Effect of Oxygen in Cast Iron;" see "Foundry Trade Journal," April, 1914.

† See page 191.

also had been referred to as a eutectoid. He understood that pearlite was formed when the whole mass was solid, and although there was the chemical evolution of heat, that evolution did not bring the temperature up to the point of fusion. So that he really did not think that pearlite could be referred to as a eutectoid, for the simple reason that the eutectic point had been passed. He thought the charge was simply in the carbon.

Mr. J. J. Dobson stated that the lecture had confirmed his opinion that in order to produce good iron or steel the first step must be to obtain pure iron, or iron cleared of its impurities, and then put in the materials necessary to obtain the desired constitution. He produced steel castings by employing pure or puddled iron with mild-steel punchings, and scale or cinder from the finished iron. The whole was melted in crucibles, and yielded very good results, producing good sound steel which could be used without annealing.

Professor Turner, replying, said that with reference to Johnson's experiments in America on the addition of oxygen to cast iron, anyone reading that paper alone would no doubt be impressed, and would regard it as a very important contribution. But almost at the same time there were published one or two Papers by other observers, particularly in Sweden, in which it was suggested that the ill-effects of changing the blast were due to the presence of oxygen. So that one man contended that he improved the material by introducing oxygen, while another argued that oxygen deteriorated it. It was clear that more careful observations were wanted before conclusions could be drawn. Some experiments by Austen, and published in a recent issue of the "Journal" of the Iron and Steel Institute, showed the effect of oxygen on mild steel. That undoubtedly represented careful experimental work. He did not know anyone in this country who had dealt with the effect of oxygen on cast iron. His (Professor Turner's) opinion was, that however beneficial oxygen might have been to that particular iron used in America by Johnson, he would not recommend anybody in this country to put oxygen into the pig-iron. His own impression was, that as it might be presumed that the oxygen would go into solid solution, it might make an improvement up to a certain point. But when they got past that point oxygen would make the iron worse rather than better. The coke irons in this country probably had an excess of oxygen. Mr. Buchanan had asked whether the difference in physical properties of apparently similar composition was likely to be dependent on allotropic effects. He would not look to allotropy for an explanation of those changes, but would seek a more careful chemical analysis than was usually performed. Ordinary analysis might determine the amount of carbon, silicon, phosphorus, sulphur and manganese; but it did not always determine the nitrogen, copper, nickel, chromium, tungsten, titanium, or vanadium. Those elements were sometimes present in small quantities, and produced a great effect. He did not think it could be said that certain materials showing great differences had exactly the same chemical composition. It might be said that as far as the ordinary tests went they had the same chemical composition. He had had a number of samples brought under his notice containing elements not expected to be there, such as copper and titanium, and their presence was not at all uncommon, although they were usually beneficial. One speaker had asked how to produce the graphite in a small condition. They might take iron not too saturated with carbon, and it was necessary to remember that silicon to some extent took the place of carbon; therefore, the more silicon they had the less carbon would be required. Either relatively low carbon with more of the other elements, or a fairly high carbon in metal that was pure would be required. It must not be so saturated with carbon that it would tend to come out more quickly. One speaker had referred to the effect sometimes noticed in the ladle when what was called kish was got. That seemed to suggest that carbon existed in the iron in a free state in the metal in the ladle; but it did not follow because kish separated that there was free carbon in the metal. If proper time were given the carbide would decompose as it did in the malleable process. The carbide readily decomposed if kept at, or above, 900 deg. C. for some time, especially when silicon was present.

A hearty vote of thanks to the lecturer concluded the meeting.

## Chromium and Tungsten in High-Speed Tool Steel.

Discussing the effects of chromium and tungsten upon the hardening and tempering of high-speed tool steel in a Paper before the last meeting of the Iron and Steel Institute, Prof. C. A. Edwards and H. Kikkawa stated that the conclusions arrived at from the investigations they had conducted were as follows:—

The first effect of tempering hardened high-speed steels is to make them softer, but when they are tempered at higher temperatures they again become harder, and after heating at or about 614 deg. C. they are much harder than in the initial air-quenched state. There can be no doubt that this secondary hardening is the cause of the improved cutting powers of a tool which Mr. Taylor found was brought about by a secondary low heating to about 620 deg. C.

Chromium in conjunction with carbon is the cause of the great hardness of hardened high-speed steels, and further, it materially lowers the temperature at which these steels can be air-hardened.

In the absence of chromium tungsten raises the temperature at which tempering or annealing begins, and in the presence of chromium it increases the intensity of the secondary hardening, and raises the tempering temperature.

Tungsten steel containing 18.0 per cent. of tungsten and 0.63 per cent. of carbon can be air-hardened only by rapid air-quenching from temperatures above 1,050 deg. C.

When high-speed steels are hardened at low temperatures, say, 1,050 deg. C., the tempering properties approximate to those of a pure chromium steel, by softening at a low temperature, and developing little or no secondary hardening. This is due to the tungsten being undissolved and remaining inactive.

The maximum resistance to tempering and the greatest degree of secondary hardening can only be obtained by getting the tungsten into solution, and with modern high-speed steels this is not complete until a temperature of about 1,350 deg. C. is reached.

Specific gravity determinations seem to indicate that there is a direct connection between the hardness and volume of these steels. On tempering, an increase of hardness is accompanied by an increase in volume.

# The Surface Appearance of Molten Cast-Iron.

By J. E. Hurst.

Experienced ironfounders claim that the surface appearance of molten cast-iron is a delicate test as to its suitability for different types of work. Up to a certain point this is undoubtedly correct, and the general characteristics of the molten iron offer good guidance in the everyday works control of the chemical composition. Unfortunately, the observation of the surface of the iron whilst molten comes at rather too late a period in the chain of operations to allow of much alteration of the composition of the metal should it not be satisfactory, and therefore this observation in itself is far from sufficient to act as a control over the quality and character of the iron. It has, further, been suggested that the network structure of the phosphide eutectic in the final iron is indicated by this surface appearance of the molten iron.

On close examination and observation of molten cast-iron two essentially different types of surface appearance are noted. The first type presents what might be termed a dull, greasy and heavy surface: the surface appears to be coated with a dull, greasy skin. (This, of course, is not to be confused with a slaggy or kishy skin.) The second type presents a bright, mercurial surface, the whole of which is covered with rapidly-moving polygonal or tessellated patterns, breaking up and re-forming in rapid succession.

The foundryman considers that the chemical composition of the metal is largely responsible for these types of surface, and that the dull, greasy surface is generally indicative of soft metal and coincident with drawn and otherwise defective castings. The bright tessellated surface he considers indicative of hard, high-manganese, hot iron. In actual fact the character of the surface is influenced by a variety of circumstances and causes, the chief of which are the temperature and chemical composition of the molten iron.

Molten cast-iron is by no means the only liquid in which this tessellated pattern is to be observed. Soapy water, when allowed to stand, presents a beautiful example of this surface pattern. This type of surface was studied by Thompson and others, who proved it to be due to the motion of the fine, suspended particles of solid matter. The motion is due to convection currents in the liquid, the result of cooling, which ascend the central portion and descend along the walls of prismatic columns. The polygonal areas seen on the surface are the upper surfaces of these columns rendered visible by the movements of the solid suspended matter.

The pattern of molten cast-iron surfaces is doubtless of similar origin, *i.e.*, convection currents; but the manner in which they are rendered visible is much different in the majority of cases of cast-iron. Solid suspended matter is often present in many cast-irons, *e.g.*, kish; but this polygonal pattern is to be observed in cast-irons whose composition is below the eutectic percentage of carbon, which precludes the possibility of kish. The skin of oxide on the surface of molten cast-iron is doubtless the means whereby the motion of the convection currents is rendered visible. A diagrammatic representation of the cross section of a vessel of molten cast-iron is shown in Fig. 1. The convection currents move along paths as shown in the diagram, causing small depressions and "rumpling" the surface of the molten iron. At the extreme heights of their paths (*a*, *a*, *a*, Fig. 1), which are the boundaries of the upper surfaces of the prismatic columns, the currents bump against the skin of oxide with sufficient force to break through, thus momentarily exposing a small area of unoxidised metal surface, thus producing the polygonal or tessellated effect observed.

The convection currents are present in all cast-iron, and it will therefore be quite obvious that the different types of surfaces observed are due to the fact that in certain irons the motion is rendered visible, and in others it is not. The thickness of the skin of oxide largely controls the visibility of this motion, and those irons which are liable to rapid oxidation do not show the tessellated pattern. The thickness of this skin is controlled by the chemical composition and the temperature of the metal. Low-silicon, manganese, and sulphur, and, to a certain extent, low-phosphorus irons are most readily oxidised, owing to the fact that these elements tend to decompose iron oxide. In the usual commercial irons, where the phosphorus and sulphur are constant, the amount of oxidation

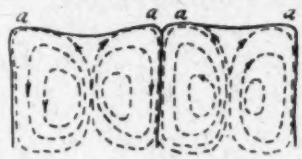



FIG. 1.

depends on the silicon and manganese contents. A high-silicon or high-manganese iron will within a certain range of temperature show this polygonal-pattern surface. With a silicon content in the neighbourhood of 2 per cent. and fresh iron at, say, 1,300 deg. C., the manganese content should exceed 0.4 per cent. before this pattern becomes visible. The addition of silicon, manganese and aluminium to molten iron with the greasy, heavy surface, produces the tessellated pattern—provided, of course, they are not added in such large quantities as to cool the metal considerably. Usually on lightly skimming this greasy metal with an iron or carbon rod the tessellated pattern under the iron-oxide skin is momentarily visible, but it immediately disappears owing to the rapid re-formation of the skin of oxide.

The temperature of the metal also influences the presence of this tessellated surface. The hotter the metal the greater the tendency of the pattern to become visible. This may be due to the increase in velocity and strength of the convection currents owing to greater rapidity of cooling, consequently enabling them to break through a thicker skin of oxide; but in addition it may be due to the fact that there is a somewhat less liability to surface oxidation at high temperatures. The character of the pattern also changes with the temperature. When the metal is exceedingly hot the pattern is much more closely woven, and, in addition to the polygonal markings, the diagonals of the polygons are also rendered visible and the markings seem to radiate from numerous centres. This may be due

to the increased strength and number of the upward currents. On cooling down the diagonal markings gradually disappear, leaving the polygonal markings only.

The size of the containing vessel would seem to largely influence the size of the polygonal areas. In a large ladle the polygons are of a much greater area than with the same metal in an ordinary hand shank. Often in the large ladle the surface appears to be of the dull, greasy type, and when transferred to the small shank the polygonal pattern makes its appearance. This may be due to excessive oxidation of the large surface of metal exposed to the atmosphere.

As the iron cools down the convection currents gradually become weaker, till at the solidification point they altogether cease. The oxide is left in tiny heaps at the centre of the polygons, and for a short time the surface of the hot, solid iron is covered with a speckled pattern of iron oxide, and afterwards the whole of the surface gradually becomes coated with a skin of oxide, often masking this speckled pattern.

The visibility of the pattern in normal irons at a given temperature depends on the thickness of the oxide scum on the surface. In an iron at a given temperature, and given phosphorus and sulphur content, the presence of the tessellated pattern indicates high-silicon or manganese content. Whether the convection currents, and therefore indirectly the tessellated pattern, have any influence on the final structure of the cast-iron is a question that has not been settled; but it may be necessary to point out that the pattern observed in molten cast-iron is not due to the motion of phosphide eutectic in the molten metal, and that it does not influence the network structure of this phosphide eutectic in the final iron.

## Stellite.

The following is an abstract of a Paper presented by Mr. Elwood Haynes at the recent annual meeting of the American Institute of Metals :—

The name Stellite was first applied to a binary alloy consisting of cobalt and chromium, which the writer discovered and produced as early as 1899. It was not until some years later that its properties were fully investigated, when it was found to possess the following properties:—

(1) A considerable amount of hardness, as alloys containing 10 per cent. or more of chromium could not be successfully filed, though the file could slowly wear away the surface of the metal.

(2) Considerable toughness; alloys containing as high as 25 per cent. chromium showing elongation of 10 per cent. or more.

(3) Comparatively high tensile strength and elastic limit: a bar of forged metal showing elastic limit of 85,000 lbs. and tensile strength of 110,000 lbs.

(4) Fine colour and lustre. The colour of the alloy lies between that of steel and silver.

(5) Absolute resistance to oxidation or other changes when exposed to either dry or moist atmosphere at all temperatures under a dull red heat.

In 1911 the writer succeeded in producing very hard alloys (consisting essentially of cobalt and chromium) by adding tungsten or molybdenum or both. The hard alloys thus formed could not be scratched with the file, but in turn would scratch any steel that could be produced. Some of these alloys were extremely brittle, and those used for lathe tools require very careful handling. Some of them that showed excellent cutting qualities when used for turning cast iron or steel would break very easily if subjected to any abnormal stress.

In order to determine the stress required to break a $\frac{3}{8}$ in. sq. tool, for example, a small clamp was made in the form of a slot precisely similar to the slot used in the tool holder. A short piece or bar of Stellite was placed in this slot and pressure applied vertically near the end of the bar at a distance of 1 in. from the clamp. Some of the weaker bars broke at from 100 lbs. to 300 lbs. pressure under this test. Gradually the strength of the bars was increased until they would readily withstand 1,000 lbs., and at this time bars are produced for turning steel which readily withstand from 1,200 to 1,500 lbs. under the same test. The very hard bars used for turning cast iron usually stand from 800 to 1,200 lbs. under this test. Bars that would stand as high as 1,850 lbs. have been produced, but were not found to be equal in cutting qualities to some other compositions of slightly less strength. It should be remarked at this point that the cutting qualities of any steel do not depend primarily upon its strength, but upon the suitable combination of strength, hardness, resistance to wear, etc. The strength of a tool is in reality a question of elastic limit. Steels possessing this quality to the highest degree are nickel steels, nickel-chrome steels, and vanadium-chrome steels. For turning steel and iron, however, they are of little or no value, since they lack in hardness and resistance to abrasion, particularly at high temperature.

The virtue of the Stellite tool lies in its ability to maintain its cutting edge at a high rate of speed at temperatures which would immediately cause the failure of any known tools containing any notable quantity of iron. Its great hardness and resistance to abrasion at all working temperatures are likewise valuable properties.

Owing to the fact that Stellite retains its hardness even at a full red heat, it cannot be forged. This fact, however, is rather a virtue than a detriment so far as use is concerned, because if the alloy would soften sufficiently for forging when heated it would, of course, immediately lose its cutting edge at the same temperature, and this would limit its usefulness to a marked degree. Owing to this characteristic, Stellite can only be reduced to the desired form by casting it in dies in the form of bars which are afterwards ground to a cutting edge. Its capabilities as a lathe tool are now universally acknowledged, though in certain cases failures have resulted, due to improper knowledge of the alloy and its peculiarities. It should be remembered that it is not a steel, and therefore requires special handling, which enables the operator to utilise its valuable properties to the best advantage.

**PROTECTION OF IRON BY ENAMELLING.**—A method of enamelling iron, described by M. P. Wood, is as follows :—The metal is first pickled in hydrochloric acid to free it from foundry scale, then washed thoroughly and dried. The first coating applied is composed of 34 parts silica, 2 parts soda, and 15 parts borax, mixed in water. The metal thus coated is exposed for 10 to 15 min. in a dull-red-hot retort. A second coating is then applied, consisting of 34 parts feldspar, 19 silica, 24 borax, 16 oxide of tin, 4 fluorspar, 9 soda, and 3 saltpetre. This mixture is first melted in a crucible, then ground to a fine paste in a little water and applied with a brush. The coated piece is then again subjected to white heat in a muffle. It is claimed that the enamel unites with the iron and that pipes thus enamelled have been in use for many years without deterioration.

## Properties and Uses of Tungsten.

The following notes are taken from a publication issued by the United States Geological Survey :—

Tungsten has a very high specific gravity or density, which ranges from 19.3 to 20.2, the figures depending on its treatment. The specific gravity of iron is 8. A piece of tungsten, therefore, weighs more than twice as much as a piece of iron of the same size. The melting-point of tungsten is so high that it cannot be melted directly into a mass, and for this reason it is obtained from its ores only as a metallic powder. By indirect means it can be worked into solid masses ranging from wire 0.0002 in. (0.005 millimetre) in diameter* to more equidimensional pieces weighing 2 or 3 lbs. The processes used will probably be improved, so that larger pieces may be made if there is sufficient call for them.

Tungsten does not oxidise readily and is practically insoluble in the common acids. Its hardness varies from 4.5 (razor steel is from 5 to 5.5) to 8. It is therefore harder than quartz, which has a hardness of 7. It is, in fact, as hard as topaz. Tungsten forms alloys with other metals and gives to steel both hardness and the property of holding its temper under higher temperatures than will carbon steel, and it is most largely used as an alloy of steel. The following table, given by Fink, shows comparatively the properties of aluminium, copper, nickel, iron and tungsten :—

| | Density at 18° C. | Coefficient of expansion at 18° C. | Tensile strength in pounds per square inch. | Modulus of elasticity in pounds per square inch. | Specific heat in calories 1 gram -1° C. | Melting point in °C. | Elec. resis. in microhms per cu. cm. |
|---|---|---|---|---|---|---|---|
| Aluminium | 2.7 | 21.8 by $10^{-6}$ | 43,000 | 10 by $10^{6}$ | 0.214 | 660 | 2.62 |
| Copper ... | 8.87 | 15.9 by $10^{-6}$ | 66,000 | 19 by $10^{6}$ | 0.091 | 1,083 | 1.589 |
| Nickel ... | 8.75 | 12.7 by $10^{-6}$ | 96,000 | 29 by $10^{6}$ | 0.10 | 1,453 | 6 93 |
| Iron ... | 7.8 | 11.2 by $10^{-6}$ | 450,000 | 30 by $10^{6}$ | 0.105 | 1,600 | 8.85 |
| Tungsten | 19.6 | 3.5 by $10^{-6}$ | 610,000 | 60 by $10^{6}$ | 0.034 | 3,267 | 4.42 |

NOTE.—The values given for iron in the third and fourth columns are for high tensile strength steel. As for the tungsten values here recorded, the specific heat figure is that of Honda, the melting point that of Langmuir; the others were determined by the writer.

For alloying steel both tungsten and ferro-tungsten are used. Ferro-tungsten is an alloy of iron and tungsten, carrying 50 to 85 per cent. tungsten. It is claimed that less tungsten is lost when it is introduced into steel in ferro-tungsten, and in general ferro-tungsten can be made more easily than tungsten. Tungsten is used largely instead of platinum and platinum-iridium alloys as contact points in spark coils, voltage regulators, telegraph relays, and spark plugs for automobiles. Fink has described other uses and possible uses as follows :—

Electric laboratory furnaces with tungsten resisters are of two types. In one a tungsten wire is wound on an aluminium tube in an air-tight box with a hydrogen atmosphere. In the second a tungsten metal tube takes the place of the helical carbon resister in an Arsem vacuum furnace. For thermo-couples the tungsten-molybdenum couple is interesting. The electro-motive force increases with the temperature up to about 540 deg. C. (12½ millivolts), then decreases and passes through 0 millivolts at about 1,300 deg. C. This couple is very convenient for high-temperature measurements in the tungsten-hydrogen furnace. For standard weights tungsten is also well suited, since wrought tungsten can be made so hard that it will readily scratch glass and still be ductile; furthermore, the density is high (19.3 to 21.4), and it is unaffected by the atmosphere. Tungsten weights remain wonderfully constant. Besides the applications of tungsten cited above, many others have been but partly worked out and others merely suggested. Owing to its chemical stability the finest sizes of wire down to 0.0002 in. or 0,005 millimetre in diameter are well adapted for galvanometer suspension and for cross hairs in telescopes. Acid-proof dishes and tubes have been made out of tungsten; furthermore, tungsten wire recommends itself as a unit resistance, since it can be made absolutely pure, can be easily duplicated, and is not corroded.

Finally, Fink mentions tungsten writing pens, tungsten drawing dies, tungsten knife blades, tungsten reinforced asbestos curtains and fireproof coverings, and other articles. The valves of some automobile engines are made of an iron-tungsten alloy and are said to stand the wear much better than iron or steel.

* Hairs from the human head ordinarily range from 0.0012 to 0.003 inch (0.03 o 0.075 millimeter) in diameter.

## Oxide Films and Pits in Gunmetal.

In the course of a Paper presented at the Annual Meeting of the American Institute of Metals in 1915 on the relation of the mechanical properties of zinc-bronze to the microstructure, MR. HENRY S. RAWDON remarked that the one predominating cause of low results, as illustrated by the series examined, was the presence of oxide inclusions. In speaking of this point Law says: "So important is the deoxidation of metals and alloys, that it would probably be no exaggeration to say that when the history of the alloy industry comes to be written the record of progress during the past twenty years will be summed up in the words 'the use of deoxidisers.'"

The form in which an impurity occurs, rather than its actual amount, continued Mr. Rawdon, largely determines the deleterious effect produced. The work of Heyn and Bauer has shown that in the copper-tin alloys stannic oxide inclusions occur in the form of an intersecting network. Similar networks were found in many of the samples examined, and in many of these networks dove-grey inclusions were found; most of them, however, were filled with a pulverulent form of oxide. The oxide is really in the form of films of which the network observed is the cross-sectional view. These films are found within the dendritic structure of the crystals, in the tin-rich portion or in that portion solidifying toward the close of the solidification period. Consequently they are found in conjunction with the eutectoid, which was often noticed to form a continuation of the film. Thus the bad effects of each are enhanced. In addition to the oxide films most of the specimens showed porosity to a greater or less extent. In many cases these pores were filled with the same pulverulent form of oxide found in the films.

For a series of 44 specimens examined in detail the results show that of those having an ultimate tensile strength of 30,000 lbs. per sq. in. or less, 13 in number, all show numerous oxide films and pits. Of the 12 specimens having an ultimate strength of from 30,000 to 35,000 lbs., 10 show evidence of the films of oxide. Oxide films and pits were found to be rare or lacking in those specimens showing a high ultimate tensile strength, *e.g.*, 40,000 to 45,000 lbs. per sq. in. The presence of oxides of tin (and zinc?) in the form of pits and

films may be considered, then, as the predominating factor in the cause of weakness in cast bronze. The colour of the freshly-broken fracture suggests that often cuprous oxide may be present. Of the two, the films are much more serious in the results than are the pits and blow-holes. Samples in which the oxide occurs in relatively large masses rather than thin, wide-spreading films, while possessing a lower ultimate strength and elastic limit than sound metal, showed evidence of higher ductility, and, on the whole, appeared as a much better grade of material than those in which the films predominate.

The question of the solubility of oxides in metals is of prime importance in the consideration of means to be taken for their elimination. Law states that with the exception of cuprous oxide, the solubility of which is well known, other oxides do not dissolve to any appreciable extent in the corresponding metal. Heyn and Bauer found in their work on stannic oxide that it is not soluble in the alloy of copper and tin. The form in which the oxides were always found to occur in this study, either in pits or films, suggests strongly that they are held in mechanical suspension rather than in true solution. The work of Heyn and Bauer has shown that a covering of charcoal is not a sufficient protection against oxidation for copper-tin alloys. The results here obtained suggest that zinc as a deoxidiser is not to be depended upon without more elaborate precautions than can usually be taken in the ordinary course of brass-foundry work.

The general conclusion of the study of the microstructure is that of the causes of weakness the presence of oxides far outranks any of the others enumerated in the results produced. From the standpoint of microstructure, the variations in methods of casting, pouring temperature, etc., are to be regarded primarily as means for the production of sound oxide-free material. The frequent occurrence of oxides in this series prepared under careful supervision and using precautions for avoiding such contaminations suggests the abundance of such inclusions in similar alloys as prepared commercially. The failure of such cast alloys for many purposes is most probably to be ascribed to the presence of oxide films rather than to any other cause.

## Education of Youths Before and During Apprenticeship.

In a Paper read before the North-East Coast Institution of Engineers and Shipbuilders, on February 25, Mr. V. A. Mundella, M.A. (Principal of the Technical College, Sunderland), emphasised the need for a reorganisation of our national system of education, and prophesied that the return of peace would compel the nation to deal with the subject. Remarking that in the past we had been too prone to divorce the general education of a boy from the training necessary for the efficient carrying on of his chosen profession or trade, the author proceeded to comment upon the present provision of continued education for boys from elementary schools, and to urge the necessity for pre-apprenticeship training.

Continuing on the necessity for some form of compulsory continued education, the author said:—Three main methods have been suggested to encourage boys to continue their education both after leaving school and during their apprenticeship:—(1) Persuasion. This, as we know from experience, only affects a very small minority of the total number of boys. (2) Employers making it a condition of service, or by offering rewards, such as money or other prizes, scholarships, and fees. The first is regarded as too drastic to be adopted by every employer and the second is non-moral, and, like persuasion, is not a solution of the problem. (3) Compulsory time off to attend classes without deduction of wages. The advantages of this method are obvious:—(*a*) It does not reduce the supply of labour; (*b*) it does not reduce the family income; (*c*) it produces no undue strain on the boys.

The author went on to say that in his judgment the evidence is overwhelming that the real basis of an effective system of continued education is compulsion in some form or other. Out of many reasons for this judgment he selected the following:—

To leave the education of a young workman to the chance of finding suitable classes at hand, and to the possibility of his always being free to attend them regularly and punctually, is neither just to him nor provident of our resources.

It is quite reasonable to demand that a boy should continue his education after leaving the compulsory elementary school in order that all the labour and public money that has been expended on him should not be wasted. The State, for its own sake, takes him in hand up to about 14 years of age, and in its own interest it must continue to do so until he reaches manhood.

A large proportion of the present attendance in existing classes is due to compulsion either by employers or parents. It is sometimes argued that compulsion makes *unwilling* students, and that only *willing* students can be helped; but good teaching methods will in most cases turn an unwilling student into a willing one. Mere compulsion is a failure, but compulsion *plus* good methods is a success.

Boys cannot be compelled to work all day in the shops from 6 a.m. to 5 p.m., and then be expected to attend evening classes from 7 to 9 or 9.30. From 5.30 a.m. to 7 p.m. is 13½ hours, and it is no wonder that boys come tired and lethargic to classes after a long day of hard work and in many cases without sufficient interval for rest and refreshment. Experience proves that the value of the work accomplished in evening classes is not commensurate with the labour or expense involved by the system of evening class instruction as at present established in this country.

The only possible method is for the boys to attend classes in the daytime on two or three half days a week, and that attendance at these classes shall be regarded as part of the apprenticeship, and that there shall be no corresponding deduction in wages. It is only right and just that, if sacrifices have to be made to secure real continued education for these boys, the necessary sacrifice shall not be made solely by the boy.

The five main principles to be observed in the organisation of a complete system of continued education are:—(1) Compulsion; (2) good schools and good teachers, who should be both trained teachers who have studied expert technical work and technical experts who have been trained to teach; (3) a combination of humanistic and vocational training; (4) instruction in the daytime to be regarded strictly as part of the apprenticeship, both as to hours and wages; (5) the ideal of such schools should be the same as that of an elementary, secondary, high school or university, viz.—to inculcate qualities of diligence, self-reliance, initiative, and real patriotism, and not merely to offer some form of vocational training.

## Magnesite.

Magnesite is a natural form of magnesium carbonate that is fairly pure and free from other materials. It consists of a metallic element—magnesium—in combination with carbonic acid, or, as usually expressed, it is composed of magnesia, or oxide of magnesium 47.6 per cent., and carbon dioxide, 52.4 per cent., and is split up into these two components by heating. Pure magnesite is commonly a white, very fine-grained porcelain-like rock, which is actually minutely crystalline, but very fine and compact.

Magnesite is found in many parts of the world, the deposits of commercial importance belonging to two principal and quite distinct types. The most widely distributed type is fine-grained massive magnesite, which occurs as vein deposits. This type is associated with basic intrusive magnesium rock, which, if somewhat altered, is generally called serpentine. To this class belong the deposits on the island of Eubœa, in Greece, practically all the deposits in California, and deposits in many other parts of the world.

The other form of magnesite is of sedimentary origin, or is found in immediate relation to sedimentary rocks, in which it occurs as a massive more or less coarsely crystalline rock resembling coarse dolomite or marble in texture, an extreme phase of the supermagnesian-dolomites. The deposits of Austria and Hungary are of this type, and perhaps also the deposits near Quebec, in Canada.

Magnesite that has been calcined consists essentially of magnesia (magnesium oxide). In practice the process of calcining is carried out so as to manufacture magnesia in two forms, which have quite different properties, namely, the "caustic" calcined magnesite and the "dead-burned" magnesite. These products are obtained by different degrees of calcination of the raw magnesite.

If the magnesite be heated at moderate temperature (considerably below that required for fusion) in the furnaces commonly used for such purposes the dissociation of the magnesium carbonate into magnesia and carbon dioxide may be made fairly complete, but it may not render the residual product so inert to recombination as if it had been calcined at a higher temperature. In practice this more moderate heating, for the production of so-called caustic calcined magnesite, is so conducted that, although most of the carbon dioxide is driven off, from 3 to 8 per cent. is intentionally left combined in the residue. The calcined product then partakes somewhat of the properties of caustic lime, which is produced by similar heating of limestone, and, like lime, the magnesia is also susceptible to reaction with water and with carbon dioxide of the air. In this form magnesia also readily combines with certain other re-agents, such as magnesium chloride, and it is upon this latter fact that its important use in magnesia cement is based.

When, however, the calcining is carried on at much higher temperature, essentially all moisture and combined carbon dioxide of the magnesia may be driven off, and the heating being carried beyond this point the material may be brought to incipient fusion. The product then obtained is known as dead-burned magnesite. Nearly all shrinkage due to the calcining is then taken up, and the product resulting is a very dense, fire-resistant, and chemically inactive substance. It will not slake upon ordinary exposure as lime and caustic magnesia do, nor will it combine with chemicals for use as cement, although it has lately been found to be susceptible to change in contact with steam. The dead-burned magnesite is used for making refractory materials, such as brick, or, in crushed form, the bottoms of open-hearth steel furnaces.

## Economy in Pattern-making.

By James Edgar.

Pattern-making costs are essentially so high that it is impossible for the small foundry or engineering concern to equip a pattern-shop; and it is doubtless the growth in the number of these small jobbing engineering and foundry firms, consequent on the rise of the motor industry, which has caused the great increase in numbers of jobbing pattern-shops. But also larger concerns which have a pattern-shop well equipped are giving out a considerable amount of their pattern-making, and claim it is cheaper than having it done in their own shop. It surely reflects discredit on the management of their own concerns, because small pattern-making businesses are not usually provided with much machinery, and what they have is usually of a poor standard. We must also consider that the job-shop does not usually attract the best class of workman, because employment in these establishments is too irregular. We have likewise to remember that a middleman's profit must be made and an additional rent paid. Also, that while workmen steadily employed at a certain class of work become proficient in it, the workman in the job-shop is continually getting all varieties of patterns to make, a condition of things good for the craftsman, but directly bad for the employer. It must be admitted, however, that the job-shop generally uses good timber.

Waste is at the bottom of a good deal of the trouble. In the job-shop there is the minimum of waste, whereas in the ordinary pattern-shop it is left to the workman to use any thickness of timber he cares. He despises dirty-looking ends, cuts twice the amount necessary to avoid knots, and leaves useful stuff lying about the machines as scrap. In the job-shops it is not so. The man is told the thicknesses required, and watch is kept that there is no loss.

One of the most frequent causes of loss in the pattern-shops is the way in which boys are allowed to spoil job after job, and for the first few years are generally given work that a "handy-man" could do. This is not so in the job-shop. The boy is an asset of importance there. He is trained to be useful and to be self-reliant from the day he begins his trade; he is as much concerned about spoiling timber or frittering away time as the journeyman. Nor must it be imagined that the boy—or man either—in a job-shop is sweated. There is no waste of time or material—that is all.

Another great factor in the cheap working of the job-shop is shop control. Many comparatively small pattern-shops have almost as many men in charge as there are actual workmen. The writer knows of one shop of forty men where there are seven foremen and charge hands, and of other shops with seven or eight men and two foremen. Then the foremen in English concerns are often men who have been advanced, not because they have shown any organising ability, but chiefly by seniority.

In the great majority of foundry and engineering pattern-shops there is no reason why the cost of pattern-making should not be much reduced, and the rather lame and self-condemnatory excuse that it is cheaper to get work done outside be abolished, by promoting young pushing fellows from the bench and adopting some of the methods of the job-shop.

## Non-Ferrous Notes.

**Brass Fittings.**—A mixture which one writer recommends for brass fittings which have to be machined is: Copper, 85 per cent.; tin, 5 per cent.; lead, 5 per cent.; zinc, 5 per cent. This is said to cast well and machine freely.

**Malleable Aluminium Alloy.**—An alloy of aluminium, patented by W. A. McAdams in France, and which is described as a malleable alloy, consists of 80 per cent aluminium, 4 per cent. silver, 8 per cent. cadmium, and 8 per cent. tin.

**Aluminium and Cobalt.**—Very little appears to be known about the effect of cobalt on the properties of aluminium. One writer claims that aluminium and cobalt are soluble in each other in all proportions, and that an alloy containing 9 to 12 per cent. cobalt is more easily worked and less corrodible than pure aluminium. The experience of others, however, does not bear this out, as an alloy aluminium 92 per cent. and 8 per cent. cobalt has been found to lack fluidity, and to be hard and brittle. With 3 per cent. cobalt the alloy was still rather short and both alloys were apparently very inferior to alloys of aluminium and copper in similar proportions.

**Gold-Coloured Bronze.**—Many attempts have been made to imitate in bronze the colour possessed by gold, but so far none seems to have been successful. One so-called gold-coloured mixture consists of 90 per cent. copper and 10 per cent. zinc. It has very nearly a gold colour, although not as rich as pure gold or its alloys. It is used when an imitation of gold is required, and there are many purposes for which it can be employed, such as, for example, in the manufacture of cheap jewellery. Another mixture has the addition of a little tin, the composition being 90 per cent. copper, 9 per cent. zinc, and 1 per cent. tin. For the majority of purposes, however, the first-mentioned alloy answers equally as well and is generally employed.

**Tantalum in Nickel.**—Tantalum does not come before the founder in the ordinary way, but one writer has recommended its use with nickel. The resistance of nickel to acids is said to be considerably increased by the addition of 5 to 10 per cent. of tantalum. An alloy of nickel with 30 per cent. tantalum, it is claimed, can be boiled in aqua regia or any other acid without deterioration. The alloy is tough, easily rolled, hammered or drawn into wire. Combined with tantalum, nickel loses its magnetic quality and the alloy has the advantage over pure tantalum in that it can be heated in the open air to a high temprature without oxidising. It is produced by mixing the two metals in powdered form, compressing them under great pressure and bringing them to a high heat in a crucible or quartz tube in a vacuum. Obviously the uses of such an alloy would be only for special purposes, as the method of production alone rules it out for ordinary foundries.

**Tellurium.**—This element (chemical symbol, Te; atomic weight, 127.5; specific gravity, 6.23; melting point, 451 deg. ±1 C.) is closely related chemically to sulphur and selenium, and though in appearance wholly metallic, it is not classed among the metals. It is brittle and crystalline, and in colour is very much like unoxidised zinc; and it is so soft that it can be scratched with a hard finger nail. It is a rare element, though probably more plentiful than selenium, but, unlike selenium, it is found native in easily distinguishable masses. Efforts have been made to use tellurium in bearing metals, but apparently without success. It has been used in colouring glass, to which it gives a peculiar reddish tint, and Samuel Wein has patented an alloy of aluminium, zinc, and tellurium. He claims that a mixture of 50 to 85 parts of aluminium, 49 down to 14 parts of zinc, and one-fourth to one part of tellurium makes an alloy that is superior to aluminium in tensile and torsional strength.

**Bismuth.**—This element (chemical symbol, Bi.; atomic weight, 208; specific gravity, 9.67-9.90; melting point, 270 deg. C.) is not a widely useful metal. Its brittleness prevents its use for anything which should be tough or malleable. It expands on solidifying from the molten condition, and on account of this property it has sometimes been used in type metal. It is used chiefly in medicine, for which it furnishes a considerable number of salts. Bismuth is extensively used in low melting point or cliché alloys, such as are used in the automatic sprinklers placed as a protection against fire in warehouses and stores, in fuses for electric wiring, and in solders. Its use in storage batteries is said to be prevented by its high price. A little is used in some bearing metals, while foundry pattern plates sometimes contain a small proportion, in order that they shall give a clear definition of the pattern—a result obtained by reason of the expansion of bismuth on solidifying.

**Copper-Nickel-Vanadium Alloy.**—A somewhat complex alloy, which it is claimed can be easily rolled, hammered, cast, stamped, and brazed, and which retains its ductility, is not corroded, is untarnishable under ordinary atmospheric conditions, and well resists most acids and sea water, was recently patented by C. R. Denton (Sheffield). The particular features appear to be the absence of lead, and the presence of vanadium and aluminium. The approximate composition of the mixture is as follows:—Copper, 86 parts; nickel, 15 parts; vanadium, 1 part; spelter, 12 parts; tin, 7 parts; aluminium, 1 part. The nickel and vanadium, together with 50 parts by weight of copper, are heated in a crucible, well stirred and mixed and brought to melting point. When properly molten, the remainder of the copper is added, and it is again brought to the molten condition. Fluxes are added, the mixture is stirred, and the spelter is introduced, the whole being then heated to 2,000 deg. F. (about 1,100 deg. F.). The tin is added next and the mixing and heating repeated, until the former temperature is reached, when the aluminium is added. The whole mixture is then well stirred and heated to 2,000 deg. F., at which temperature it is ready for pouring.

**Copper-Lead Alloys.**—These two metals do not properly alloy to any appreciable extent, the lead separating out as the metal cools and forming a separate layer if the cooling is protracted. The entectic composition, or most readily melted alloy, is that 99.94 per cent. lead, and 0.06 per cent. copper, this melting at about 1 deg. C. lower than lead. Lead and copper are partially soluble in each other when just liquid, but are quite insoluble in each other when just solid. The result is that when up to, say, 2 per cent. of lead is added to copper, it greatly weakens the latter, as it separates out and forms an almost continuous network around the copper grains. It is, therefore, interesting to recall a process which L. Sempell (Duisburg, Germany) claimed to have invented two or three years ago, and for which he took out a patent in this country. His method was to pass hydrogen iodide through the molten mixture. To produce an alloy composed of 100 kilogrammes of lead and 50 kilogrammes of copper, about 50 litres of gas containing (say) 30 per cent. of hydrogen iodide and 70 per cent of inert gas, was passed through the bath for 5 minutes. A harder final product was claimed to be obtained if the passage of the gas was continued for a longer period. The process does not seem to have found practical application.

**Preventing Oxidation During Annealing.**—A method of preventing oxidation on the surface of metals during the annealing operation, which was patented by J. F. Thompson and E. S. Seelye in America, was based on the claim that when a fusible halogen salt of an alkaline or an alkaline-earth metal is mixed with a base and spread on the article to be annealed, during the annealing operation, the article will not oxidise. A typical operation of the process was described as follows:—To boiling water is added calcium chloride to form a saturated solution of calcium chloride. The mixture is emulsified by adding ground fluorspar (calcium fluoride), and the result is a thin paste. To this may be added more water for thinning. The paste is applied to the article to be annealed either by dipping or with a brush. When the article is heated, its surfaces are kept free from oxidation, and after annealing the paste can be washed, rubbed, or

brushed off, and the surfaces of the article are found in substantially the same condition as before annealing. Two parts of fluorspar to one part of calcium chloride were given as typical proportions, the calcium chloride being the active agent and the fluorspar being the base which retains the calcium chloride on the surface of the article when the calcium chloride fluxes from the heat during the annealing process. The proportions may be varied within certain limits, and any material may be used instead of the calcium fluoride which will act as a suitable vehicle for the active agent.

**Red Brass and Porosity.**—One of the most provoking difficulties encountered in making red-metal castings, says "The Brass World," is to have them spongy. There is no doubt that deoxidisers, chief of which is phosphorus, do much to prevent the porosity trouble, but they are not infallible. It can usually be assumed that porosity originates at the furnace, because the price of successfully producing clean sound castings is eternal vigilance in melting the metal. The metal itself has a great affinity for oxygen, therefore it must be kept covered at all times when melted or melting. Sulphur is also present and is absorbed by the metal, and coming into contact with the copper oxide, takes the oxygen from the latter, forming sulphur di-oxide, which is a gas easily retained to assist in the process of turning the castings into a sponge. The sulphur really acts as a deoxidiser, but it is a very poor one to use in brass-foundry operations. A little oxide of manganese and salt mixed with the charcoal used for melting is a great help in preventing porosity, as some manganese is reduced which removes both sulphur and oxygen. The use of fluxes that melt and cover the surface of the metal is also justified, as they protect the metal from the furnace gases. The manner in which the crucibles are filled with metal should also be carefully watched. It may not be impossible to make good metal and have the pot swimming full, but it is not an easy matter by any means, as there is no room for the charcoal or other protective covering. Also the mixture cannot be properly stirred in, and the composition of the metal will vary from heat to heat as the tin or other white metal which is added melts and overflows the crucible when an attempt is made to stir the metal.

**Selenium.**—Selenium (chemical symbol, Se) is one of the rare elements. Its atomic weight is 79.2, and its specific gravity in the liquid or amorphous form is 4.26, and in the metallic form 4.8. The amorphous form becomes soft at 40 to 50 deg. C., the red crystalline form melts at about 170 deg. C., and the metallic form at 217 deg. C. Selenium was discovered by Berzelius in 1817 in a deposit in the lead chambers of a sulphuric acid plant at Gripsholm, Sweden. The acid was made from sulphur that had been distilled from Falun sulphides—mostly pyrite, though including a little copper, lead, zinc, and tin sulphide, and probably some arsenopyrite. Selenium is still obtained as a by-product, though from sources not at that time known—the anode muds formed in the electrolytic refining of copper. Selenium, as ordinarily placed on the market, is an amorphous brilliant black substance looking much like pitch or one of the asphalts. In very thin fragments it is translucent and ruby red, and in fine powder it is reddish. It is sold in small pigs, in sticks half an inch thick and about 4 inches long, and in a fairly coarse powder. It is soluble in carbon bisulphide. Selenium may be obtained as a red crystalline substance including, perhaps, two closely allied forms, also soluble in carbon bisulphide. A third form, metallic selenium, is insoluble in carbon bisulphide, and is in stable form. Metallic selenium conducts electricity when exposed to light, but when the light is cut off its electrical resistance is greatly increased. The element has been most largely used in making glass, to which it gives a red colour, but the property possessed by metallic selenium of increasing resistance to an electric current with decrease of light has been the basis of many electrical inventions. Selenium is used in instruments for measuring the Roentgen rays used in therapeutic applications; in a form of Wheatstone bridge, and for other purposes.

**Characteristics of Arsenic.**—Arsenic has for so long been regarded as an enemy to the copper user that it is interesting to review its properties. It is an element (chemical symbol As) which is generally classed among the non-metals, though it has some of the characteristics of a metal. Its appearance and lustre are metallic, and it forms with several metals compounds which, though brittle, correspond to true alloys, such as hard lead, a compound of arsenic and lead, and several varieties of speculum metal, but the addition of arsenic to most metals makes an alloy which is too brittle. Arsenic is electrically positive and is a good conductor of electricity and of heat. Its atomic weight is 74.96, and its specific gravity (crystallised) 5.73. Its melting-point under pressure is 500 deg. C.; if heated at ordinary atmospheric pressures arsenic volatilises without melting. On freshly exposed surfaces arsenic is steel grey, but it soon becomes tarnished and blackened, possibly by the formation of a suboxide, and then changes to the white arsenious oxide, $As_2O_3$,—the "arsenic" of commerce. Most of its soluble compounds are highly poisonous. In most of its mineral combinations and in all of its 90 oxygen-bearing minerals, except the simple oxides, arsenic acts as an acid-forming element. The only minerals in which arsenic may be considered to act as a base are the sulphides and possibly the oxides. The number of arsenic minerals—that is, the minerals of which arsenic forms either a major or a minor constituent—is very large, 130 or more, the exact number depending on the strictness with which definitive lines are drawn. As the known minerals number about 1,100 it will be seen that nearly 12 per cent. of them are arsenic bearing. White arsenic is used principally in glass-making. Elemental or "metallic" arsenic is used only in shot making, and only a few tons a year are consumed. It is said to make the shot rounder and harder. According to Outing, arsenic is in part replacing antimony in making "chilled shot," on account of the increased price of antimony due to the European war.

**Re-melting Gunmetal.**—It is not infrequently found that certain alloys are improved by twice melting before being poured into castings. This is particularly the case with Admiralty gunmetal, *i.e.*, Cu. 88, Sn. 10, Zn. 2. The improvement effected seems to result from the better mixing of the constituents, and, of course, is only secured if the re-melting is so conducted that the metal does not materially oxidise in so doing. Some tests on the re-melting of this alloy were recorded by a writer in "The Brass World," and the following is a summary of the results:—

| | First melt. | Second melt. |
|---|---|---|
| Composition:— | | |
| Copper ... ... ... ... ... | 87.57 | 87.56 |
| Tin ... ... ... ... ... | 10.54 | 10.57 |
| Zinc ... ... ... ... ... | 1.82 | 1.86 |
| Lead ... ... ... ... ... | 0.04 | 0.04 |
| Iron ... ... ... ... ... | 0.03 | 0.03 |
| Tests:— | | |
| Diameter of test bar, inch ... | 0.798 | 0.798 |
| Broke at, lbs.... ... ... ... | 14,400 | 17,400 |
| Tensile strength, lbs. sq. in. ... | 28,800 | 34,800 |
| Elongation, per cent. in 8 in. ... | 10.2 | 15.5 |
| Reduction, per cent. of area ... | 10.6 | 14.2 |

The above results were obtained on brass cast in green sand. The length was 13½ in., and the diameter 1¼ in., the bar being turned down in the middle for a length of 10 in. to a diameter of 0.798 m. A further bar of the same diameter, of twice-melted metal gave still higher results, as follows:—Broke at 19,500 lbs.; tensile strength, 39,000 lbs. sq. in.; elongation in 8 in., 17 per cent.; reduction of area, 20.4 per cent. The fractures of the bars which were only once melted showed a rather coarse, crystalline structure which contained fine blowholes. The metal which had been melted twice showed no blowholes and the structure of the fracture was finer grained and less crystalline than that which had been melted only once. The variation in the physical characteristics of the two test bars that had been melted twice was explained by the experimenter as being due to difference in the pouring temperature.

## Trade Talk.

THE DANISH GOVERNMENT has issued a proclamation prohibiting the export of iron.

VICKERS, LIMITED, are endowing a lectureship in Russian at the University of Sheffield.

THE EGLINTON SILICA BRICK COMPANY, LIMITED, have removed to 45, Renfield Street, Glasgow.

THE CONISTON COPPER MINES, which were closed down at the beginning of the war, have now been reopened.

THE BURDON OIL GAS FURNACES, LIMITED, are being wound up voluntarily, with Mr. S. C. Pratt as liquidator.

THE Swedish Government has prohibited the export of raw and manufactured antimony and platinum and molybdenum.

MR. W. H. PATCHELL has removed from Caxton House, Westminster, London, S.W., to 64, Victoria Street, S.W.

A MEETING of the shareholders of the Victoria Iron and Steel Company, Limited, will be held at Airdrie, on April 6, to receive the liquidator's report.

THERMIT, LIMITED, have removed their registered offices to new and commodious premises recently erected at their works at 675, Commercial Road, London, E.

BARLOW & CHIDLOW, LIMITED, are now occupying their new works in Grafton Street, Pendleton, Manchester, which have been named the Pendleton Gear Works.

MR. T. R. GIBSON, carrying on business under the style of Thomas Gibson & Son, Bainfield Iron Works, West Fountainbridge, Edinburgh, is retiring from business.

MESSRS. A. HAMBURGER and J. G. REDGRAVE, metal refiners, 67 and 68, Darwin Street, Birmingham, trading as the Acton Metal Company, have dissolved partnership.

AN order has been made by the Government for the winding-up of the Australian Metal Company, Limited, 2, Metal Exchange Buildings, Leadenhall Avenue, London, E.C.

THERE is every possibility that the Cyfarthfa Iron & Steel Works, after having been closed for many years, will be re-opened at an early date, providing sufficient labour is available.

THE MONTANIA ENGINEERING COMPANY, LIMITED, is being wound up voluntarily. Mr. F. W. Stephens, Salisbury House, London Wall, E.C., has been appointed liquidator.

A MEETING of the members of the British Manufacturers' Association, 1915, will be held at the Cannon Street Hotel, London, E.C., on Wednesday, April 5. All manufacturers are invited.

THE shareholders of Walker, Maynard & Company, Limited, decided on March 2 that the company be wound up voluntarily. Mr. F. McBain, of Middlesbrough, was appointed liquidator.

THE new works at Lifford, near Birmingham, of Frederick Mountford, Limited, Granville Street, Birmingham, are now approaching completion, and should be in operation in a few months' time.

ON March 11 Dr. W. H. Hatfield, of Sheffield, lectured to a meeting of the Rotherham Technical Engineering Society on the subject of "Cast Iron." Mr. E. H. Saniter, the president, occupied the chair.

THE partnership heretofore subsisting between Messrs. C. A. Ryder and H. B. White, engineers' merchants, 16, John Dalton Street, Manchester, under the style of Ryder & White, has been dissolved.

THE PEARSON-PAGE COMPANY, LIMITED, general brass founders, whose head offices are at Ernest Street, Holloway Head, Birmingham, have entered into possession of the Ileene Works, Sherlock Street, Birmingham.

COCHRANE BROTHERS, LIMITED, have found it necessary to still further enlarge their Bo'ness works. The firm, who have extensive contracts for horseshoes, intend installing gas furnaces instead of the usual smith's forge.

THE firm of W. G. Brown & Sons, engineers, 216, Old Shettleston Road, Shettleston, Glasgow, of which Mr. W. G. Brown, Mr. A. S. Brown and Mr. T. Brown were the sole partners, has been dissolved. Mr. W. G. Brown will continue the business in his own name.

THE LUMSDEN MACHINE COMPANY, LIMITED, Alexandra Works, Gateshead-on-Tyne, have built an extensive new works in Hawkes Road, Gateshead. It is proposed to still retain the Alexandra Works, but the head offices of the company will be transferred to the new works.

THE MINISTER OF MUNITIONS announces that he has made further orders under Section 4 of the Munitions of War Act, 1915, under which 26 additional establishments have been declared controlled establishments. A total of 3,078 establishments has now been declared as controlled.

THE partnership heretofore subsisting between Messrs. F. E. Good and B. V. Marriott, carrying on business as electrical and mechanical engineers, at 4, Chesterfield Street, Nottingham, under the style of Good, Marriott & Company, has been dissolved. Mr. Marriott continues the business.

MESSRS. A. BLYDE & COMPANY, of the Wallace Steel Works, Sheffield, are supplying their "Crutch Brand" of tool steel, etc., to the Middlesbrough Corporation, during the twelve months ending March 31, 1917. The firm have held this tool steel contract for some years now, and supply all departments of the Corporation.

THE partnership heretofore subsisting between Messrs. C. R. Townsend and R. C. Turner, engineers, Wellesley Works, 49-51, Wellesley Street, and 70, Farm Street, and 57 and 58, Great Charles Street, Birmingham, under the styles of Townsend & Company and the Wheeler Foundry Companies, has been dissolved.

THE ELECTRO-FLEX STEEL COMPANY, LIMITED, of Newcastle-on-Tyne, are making very extensive additions to their works at Dunston-on-Tyne. The new melting shop and foundry will cover a floor space equal to three times that of the whole of the present works. When the new shop is finished the present melting shop and foundry will be converted into the fettling and machine shop, and the other existing buildings into auxiliary shops.

DR. ADDISON, replying to Mr. W. Thorne on March 16, said that certain complaints had been brought to notice of Belgians of military age working in the engineering shops in different parts of the country. Active steps were being taken by the Belgian Government, in conjunction with the British Government Departments concerned, to secure that single workmen who were not engaged in skilled work in munitions factories, and who were covered by the Belgian military law, should be called to the colours.

In reply to a question in the House of Commons, addressed by Mr. Anderson on March 21, DR. ADDISON said that a certain number of soldiers had been released from the colours to work as iron moulders, but none of them had been sent to F. Brotherhood, Limited. The work of moulders was specialised to a very high degree, and the fact that 200 such men were on the unemployed funds of their society did not imply that those individuals would be suitable for the particular vacancies filled by workmen withdrawn from the Army.

SIR ALFRED HOPKINSON, who presided over a sitting of the General Munitions Tribunal at Sheffield on March 11, issued a warning. He said that employers must make inquiries before engaging fresh men at this time. It was unfair on the men not to do so, as it tempted them to make false statements about themselves concerning their action, which, in these days, was a criminal offence. It was unfair to the controlled firms, who had all their work to do to get through their contracts. In future if employers were careless in this respect it would be necessary for the court to inflict very heavy penalties.

SIR P. MAGNUS having raised the subject of technical instruction, in the House of Commons last month, MR. HERBERT LEWIS replied that the Education Board had not promised that it would not in any case reduce the grant to a school during the war. It had been faced by the urgent need of economy, by which he meant thrifty management, not the cutting down of education in any vital part. The Board were

strongly convinced of the importance of maintaining the standard of technical instruction under war conditions, and developing that instruction to the highest possible point as soon as the pressure of external circumstances was reduced.

THE COUNCIL OF THE ROYAL SOCIETY announce that an unmarried chemist of military age entitled to exemption as an analytical, consulting, or research chemist should, unless he was attested before March 2, lodge a claim for exemption with the local tribunal. Men who have been attested should lodge their claims for exemption with the recruiting officer or local tribunal when called up for enlistment. When such claims are not admitted, a communication, stating all material facts in favour of the disputed claim, should be addressed to the secretaries of the Royal Society, Burlington House, Piccadilly, London, W.

THE COUNCIL OF THE CLEVELAND INSTITUTION OF ENGINEERS has decided to accept the offer of Dr. J. E. Stead, of £500 as the nucleus of a fund for the establishment of a research laboratory at Middlesbrough, and the scheme is to be pushed forward. A small committee has been appointed for the purpose of considering ways and means whereby the project can be successfully carried out and the necessary financial assistance secured. It will be remembered that Dr. Stead estimated that the initial cost of the laboratory would only be a few thousand pounds, and that the annual cost of maintenance would amount to about £500,

THE annual dinner of the Smethwick Branch of the Friendly Society of Ironfounders was held on Saturday, March 4, Mr. W. J. Vaughan (president) in the chair. The toast of "The Friendly Society of Ironfounders" was proposed by Mr. Evan Gwynne, who said that the society was practically the oldest trade union in the kingdom. Mr. A. Burton, who replied, urged the members to continue making provision for the slump which is sure to come after the war. Their society had seen the wisdom of paying extra contributions while the members were in full employment, instead of leaving it to the fewer members in employment when trade was bad.

DURING the last few months efforts have been made by the Minister of Munitions to fix, by agreement with makers, a maximum price for Scotch hematite pig-iron. The price of £6 2s. 6d. per ton was suggested some time ago, but was not acceptable to the makers in consequence of the conditions then prevailing, and the market price has since advanced to 140s. per ton f.o.t. The makers again discussed the matter with a representative of the Ministry of Munitions in London on March 9, and though no definite information is available as to the result of the conference, it is understood that under certain conditions, which have not been disclosed, the maximum price was fixed at £6 2s. 6d. per ton.

THE output of pig-iron, sleepers, chairs, pipes and other castings at the works of the Bengal Iron & Steel Company, Limited, has largely increased during the last 12 months, while the ore workings have developed satisfactorily. The new electric power house, the new roof over the pig bed, with overhead travelling crane, and the new turbo blower have all been put into operation, and the new sleeper foundry and general stores are nearing completion. A 250-kilowatt generating set for the power house has been purchased, and will shortly be shipped. A fourth blast furnace and two hot-blast stoves are under construction, and will, it is hoped, be ready for use about the end of the current year.

AN arrangement has been completed by which the bulk of the shares in the Celtic Collieries, Limited, are secured by a number of Cardiff gentlemen. The intention is that the present board of directors will retire, and the control of the collieries will be taken over by a board consisting of Lord Rhondda (chairman), Messrs. H. S. Berry, J. P. Cadogan, C. P. Hailey and E. Plisson. The sale of the coal will be in the hands of Lysberg, Limited, who are also agents for the Glamorgan Coal Company, Limited, the Pitwood Syndicate, Limited, the Chargeurs Français, and a number of other companies. The Celtic Collieries, Limited, formerly known as Elder's Collieries, Limited, work the Garth and Maesteg Pits at Llangynwyd, near Maesteg. The company was incorporated 16 years ago, but until 1910 met with little success.

THE CONTROLLER OF THE FOREIGN TRADE DEPARTMENT desires to call the attention of houses engaged in foreign trade, to the Royal Proclamation published in the "London Gazette," containing a statutory list of firms of enemy nationality or association with whom all dealings by persons carrying on business in this country are prohibited. This list will be supplemented and revised from time to time. Transactions with persons on the statutory list are prohibited subject to the same penalties as transactions with firms in enemy countries, except in cases where a general or special licence has been granted, permitting the transaction. Any application for a licence should be addressed to the Controller, Foreign Trade Department, Lancaster House, St. James, S.W. In making application for licences it is requested that the following particulars may be given in each case: (1) The name and address of the applicant; (2) the name and address of the buyer; (3) the date of the order of the goods; (4) the nature of the goods in question; (5) the prospective date and port of shipment; if ready for shipment marks and numbers should be given, and the name of the actual consignee; (6) whether the goods are seasons goods, and, if so, when the season for them commences; (7) all other current orders from the same buyer. The envelope should be marked "Application for licence."

ON March 13, the new Technical College at Cardiff, which has been erected at a cost of over £60,000, was formally opened by the Lord Mayor. Amongst those present at the ceremony were:— Lord Pontypridd, Lord Rhondda, Sir William Crossman, Mr. J. Herbert Cory, M.P., Mr. Trevor Jones (high-sheriff), Colonel C. S. Denniss, Mr. J. Lynn Thomas, Mr. Lovat-Fraser, Mr. George David, Mr. C. Jones, Mr. A. Johnson, Mr. H. Farr, Principal E. H. Griffiths, and Mr. C. H. Priestley. At the luncheon which followed, Lord Rhondda, replying to one of the toasts, remarked that the character and capacity of a man depended on his inherent brain power and on the environment in which he was brought up. The college would provide the proper environment, and that would be a tremendous asset upon which to build high hopes of the future work of the college. It is interesting to note that since the Cardiff Technical School was reorganised in 1908, each year has brought its increase. The number of students has doubled, and the number of student hours has increased four-fold. The grants earned compared as follows:—1907-8, £2,082; 1913-14, £4,103; 1914-15, £4,229. There were 6,000 students under the Cardiff technical system. The new building will facilitate the work by gathering into one commodious centre the classes which have been distributed among seven distinct buildings. The building is in the form of three sides of a square, the fourth being reserved for future extension when necessary. Two rows of workshops, top-lighted, have been erected in the area between the north and south wings and parallel to them, while the assembly and examination hall binds all together.

IN issuing badges for the purpose of protecting the indispensable labour of firms engaged on important War Office contracts, the Army Contract Department has never lost sight of the importance of securing every available man for the Army; and on the institution of the Derby scheme of group enlistment the policy of badging was to a great extent abandoned, except in certain special cases, in favour of an alternative system of protection, which was thought likely to yield a larger number of recruits. Under this alternative method, firms applying for badges were urged to induce their employés to attest under the group system, with the assurance that they would have an opportunity of appeal at the time of calling up, and that the cases of their indispensable men would be carefully considered by the local tribunal. A very large number of firms have adopted this policy, and have received a letter which they could show to the tribunal stating that they held important War Office contracts, the execution of which must not be jeopardised, but at the

same time emphasising the point that the indispensability of any particular individual must be determined by the tribunal. At the present time a systematic inspection is being carried out as rapidly as possible of firms whose employés have received badges, with a view to withdrawing any which may be found to be no longer required; and the inspectors are instructed to pay special attention to the necessity of withdrawing badges from eligible single men in all cases where they can be replaced by men over age or otherwise disqualified for service or by women. As it has been suggested that the issue of the letter referred to above may have led the tribunals to adopt a too liberal policy of exemption, all firms to whom this letter was sent are also being visited in order to make sure that only men absolutely indispensable for war work have been put back. The issue of further badges is being limited to cases in which the Department has satisfied itself by investigation as to the indispensability of the individuals for whom protection is asked.

## Speculation in Metals.

At the beginning of last month the Government issued a new regulation designed to put an end to transactions in the nature of speculation in metals which are or may be required for war munitions. It is an addition to Regulation 30A, under the Defence of the Realm Act, and is in the following terms:—

30B. It shall not be lawful for any person, on his own behalf or on behalf of any other person, to sell or buy or to offer to sell or buy—

(a) any of the following metals:—Iron (including pig-iron), steel of all kinds, copper, zinc, brass, lead, antimony, nickel, tungsten, molybdenum, ferro-alloys, or

(b) any other metal which may be specified in an Order of the Admiralty or Army Council or the Minister of Munitions as being a metal required for the production of any war material, unless in the case of a seller the metal to be sold is in the possession of the seller or is in the course of production for him, or in the case of a buyer the purchase is made for or on behalf of a consumer.

(c) Provided that it shall be lawful for the Admiralty or Army Council or the Minister of Munitions by order to exclude from the provisions of this regulation any of the metals above mentioned, and whilst any such order remains in force this regulation shall have effect as if such metal were not mentioned therein.

An official explanation of the new regulations was issued later as follows:—The Ministry of Munitions wishes it to be clearly understood that the object of this regulation is to stop speculation in metals generally and not to restrict legitimate trading. In view of the representations which have been made to the Ministry of Munitions, the following particulars are published for general information and guidance:—

1. The regulations will not be enforced in the case of purchases made outside the United Kingdom until the metal actually reaches this country.
2. Export orders and sales to Allied or neutral countries through authorised channels will be treated as consumers' orders.
3. It is permissible for merchants, warehousemen and retailers to replace metals sold after March 1, 1916, by the purchase of an equivalent quantity of the same metal, but not more, although the metal so purchased may not be the metal actually delivered against the sale.
4. Transactions will not be permitted except under special licence from the Ministry of Munitions in the following:—Scrap from high speed steel, scrap from copper, scrap from brass. Transactions in other scrap metals do not require a licence.
5. Consumers may buy for their own consumption only.

## Munition Tribunals.

The Special Arbitration Tribunals which the Minister of Munitions is empowered to constitute by Section 8 of the Munitions of War (Amendment) Act, 1916, have now been set up.

These tribunals will deal with differences arising in connection with the exercise of the powers given to the Minister by the new Act in respect of the wages, hours, and conditions of employment of women or of semi-skilled and unskilled men.

Under Section 6 of the amending Act where female workers are employed on or in connection with munitions work in establishments in which leaving certificates are necessary, the Minister has power by order to give directions as to the rate of wages, as to the hours of labour, and as to the conditions of employment of these females workers. The Special Arbitration Tribunal, to which differences relating to these matters may be referred, has been constituted as follows:—Mr. Lynden Macassey, K.C. (chairman), Mr. Ernest Aves, Mr. F. S. Button, Miss Susan Lawrence, Mr. Allan M. Smith, and Mrs. Streatfeild.

Under Section 7 of the amending Act the Minister may by order give directions as to the rate of wages or the hours of labour or the conditions of employment of semi-skilled and unskilled men employed in a controlled establishment on munitions work of a class which before the war was customarily undertaken by skilled labour, and in the same way he may give directions as to the time rates paid for the manufacture of the complete shell and fuses and cartridge cases in a controlled establishment in which this manufacture was not customary before the war.

The Special Tribunal to deal with differences arising in connection with these matters consists of Mr. Lynden Macassey, K.C. (chairman), Mr. Charles Duncan, M.P., Mr. W. H. Hutchinson, Mr. Allan M. Smith, and Mr. J. C. Ward.

An additional function of each of these Tribunals is to advise the Minister, on being consulted by him, as to what directions he should give in respect of the matters specified above.

The chairman and three other members of the Tribunal form a quorum, and in case of equality of voting the chairman has a second vote.

## Trade After the War.

The President of the Board of Trade has decided to appoint Committees to consider the position of certain important British industries after the war, especially in relation to international competition, and to report what measures, if any, are necessary or desirable in order to safeguard that position.

The following Committees have been constituted:

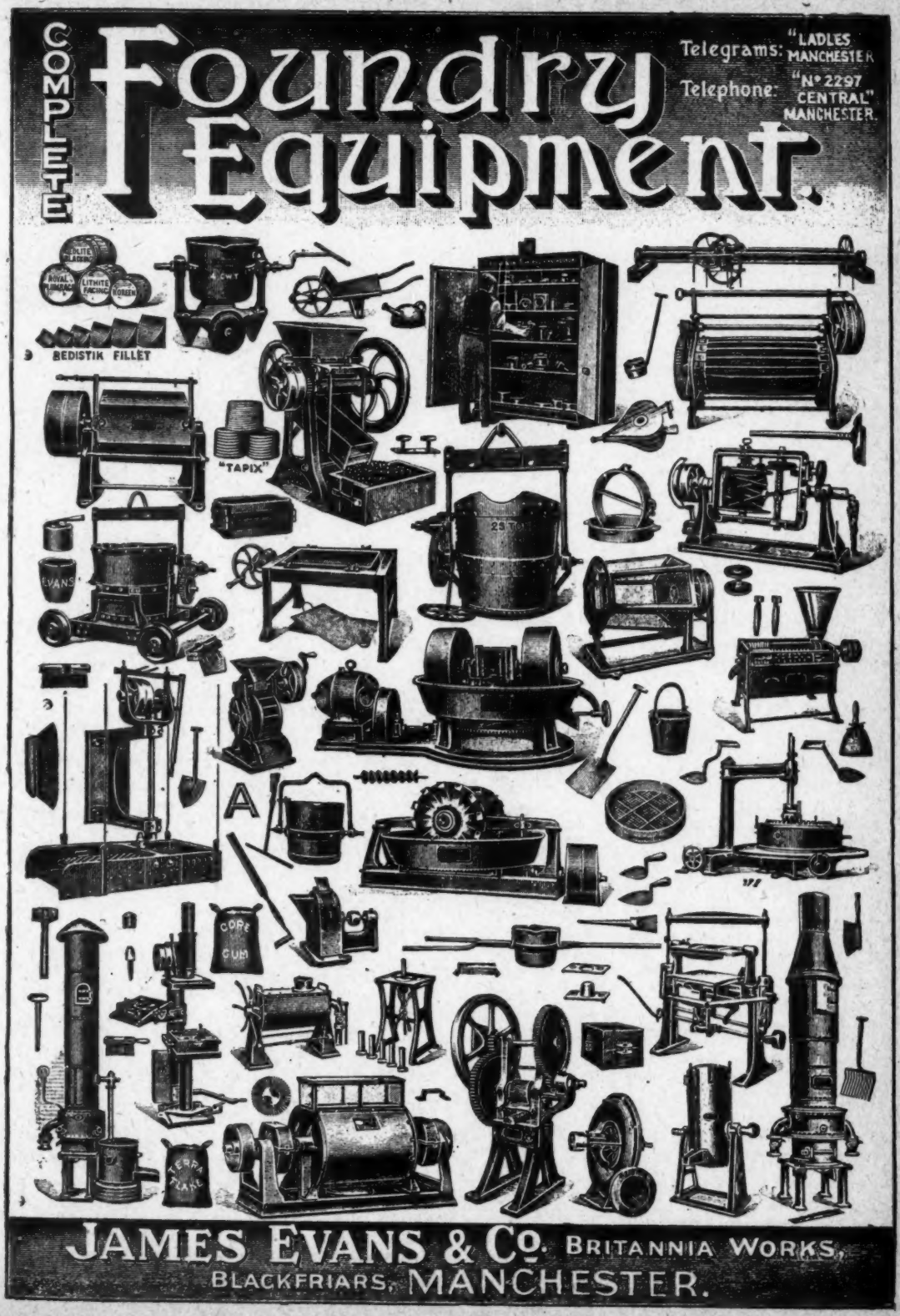
FOR THE IRON, STEEL, AND ENGINEERING INDUSTRIES.

Sir Clarendon Hyde (chairman),
Mr. A. Balfour,
Sir Hugh Bell, Bart.,
Mr. A. J. Hobson,
Sir Hallewell Rogers, and
Mr. Douglas Vickers.

FOR THE SHIPPING AND SHIPBUILDING INDUSTRIES.

Sir A. A. Booth, Bart. (chairman),
Professor W. S. Abell,
Sir Archibald Denny, Bart.,
Sir Edward Hain,
Captain H. B. Hooper,
Mr. James Readhead, and
Mr. Oswald Sanderson.

All communications relating to these Committees should be addressed to Mr. Percy Ashley, the Board of Trade.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BLACKFRIARS, MANCHESTER.

## Deaths.

Mr. R. M. McDougall, of the firm of John Miller & Company, Glasgow Copper Works, Glasgow, died on March 12, in his 71st year.

Mr. W. S. Laycock, of the firm of W. S. Laycock, Limited, and Cravens, Limited, Sheffield, has died at his residence, Oakbrook, Fulwood.

The death took place on March 4 at his residence, Hare Street, Rochdale, of Mr. Richard Spencer, at the age of 63. He was managing director of the Britannia Ironworks, Rochdale.

The death has occurred at Sevres, Paris, at the age of 71, of Mr. T. C. Hounsfield, who for upwards of fifty years has been the sole representative in that city of William Jessop & Sons, Limited, Sheffield.

Mr. Peter Harper, senior, one of the original partners of the firm of Harper & Company (now Harpers, Limited), engineers, Aberdeen, died on March 7, aged 80 years. The deceased, who was a native of Turriff, had been connected with the engineering firm which bore his name for many years.

Mr. A. Watt, chairman of the firm of Messrs. Fullarton, Hodgart and Barclay, engineers and ironfounders, Paisley, has died at his residence, Inchcape, Mansion House Road, Paisley. He was in his seventy-sixth year. Mr. Watt, who was a native of Arbroath, entered the service of the firm forty-six years ago. He was then employed in the capacity of a foreman, and subsequently became a partner.

The death has taken place at his residence, Westholme, Chapeltown, near Sheffield, of Mr. William Barraclough, late secretary to Newton, Chambers & Company, Limited, Thorncliffe Iron Works, near Sheffield, at the age of 77 years. He entered the offices when a boy, and enjoyed the confidence of the directors until his retirement in 1909.

Mr. T. Turner, J.P., died at Scofton House, Worksop, on March 18. The deceased was formerly a prominent cutlery manufacturer in Sheffield, and was Master Cutler upwards of forty years ago. Mr. Turner, who was 87 years of age, was for many years head of the firm of Thomas Turner & Company, cutlery, file and steel manufacturers, Suffolk Works, Suffolk Road.

Mr. W. H. Lloyd died on March 13 at his residence, Hatch Court, at the age of seventy-six. Mr. Lloyd was the youngest son of the late Mr. Samuel Lloyd, ironmaster, Wednesbury, and a brother of Mr. Samuel Lloyd, of Farm, Sparkbrook. He was one of the founders of the Weldless Steel Tube Company, Limited, and engaged in business at Wednesbury for the greater part of his life, but retired about fifteen years ago.

The death took place on March 18 of Mr. J. T. Hogg, head of the firm of Messrs. J. T. Hogg & Company, engineers, iron and brass founders, Barry Dock. The deceased went to Cardiff from the Tyne district many years ago, and joined Mr. J. F. Proud in an engineering business at the Docks. Subsequently a branch was opened at Barry Dock, of which Mr. Hogg became proprietor.

Mr. E. Handcock, Cardiff, has died after an illness extending over several months. In addition to being a prominent ship owner, the deceased was a director of the Cardiff Channel Dry Docks and Pontoon Company, Limited, the Bute Shipbuilding, Engineering, and Dry Dock Company, Limited, the Barry Graving Dock and Engineering Company, Limited, the Mercantile Pontoon Company, Limited, and the Tredegar Dry Dock and Wharf Company, Limited.

The death occurred at Rosemond, Westoe, of Mr. G. T. Grey, former mayor of the borough, and head of the Holborn Engineering Works. Several weeks ago, while superintending work his men were doing on a vessel at Sunderland, Mr. Grey was severely scalded, and since then has been under medical treatment at his home. He appeared to be making satisfactory progress, but had a sudden relapse, and expired shortly afterwards. The deceased was about 65 years of age. In 1882 he established the business, which later developed into the Holborn Engineering Works.

## Personal Paragraphs.

Mr. W. N. Baines, of Elsinore, Yeovil, has been elected a director of Petters, Limited, of Yeovil.

The late Mr. T. Clarke, of the firm of Thomas Clarke & Sons, Bridge Foundry, Attercliffe, left £19,289.

The late Mr. Z. Merton, a director of Henry R. Merton and Company, Limited, left estate valued at £149,865 gross and £121,889 net.

The Friendly Society of Ironfounders has decided to present Mr. Arthur Henderson, President of the Board of Education, with his portrait in oils.

Mr. C. A. Cochrane, chairman of Cochrane & Company, Limited of Middlesbrough, has been elected as the Liberal member for the Parliamentary vacancy at South Shields.

Mr. W. A. Scott, works manager of Bruce Peebles & Company, Limited, Edinburgh, has been the recipient of a presentation from the officials and men on the occasion of his marriage.

Mr. R. Bertram, of the despatching and receiving department, who has completed 50 years' service at the Woolwich Works of Siemens Brothers & Company, Limited, has been the recipient of presentations from the directors, officials, and men.

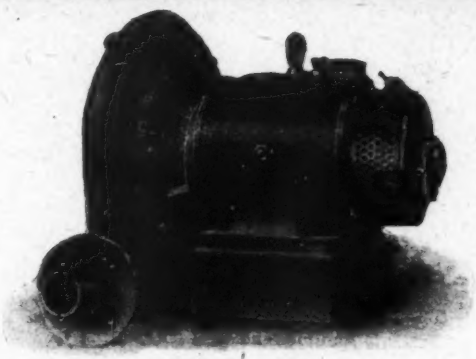
Mr. A. G. Foster, the general manager of Craven's, Limited, Darnall, who is leaving Sheffield, after five years' stay, to take up a position with Clayton & Shuttleworth, Limited, of Lincoln, has been the recipient of a presentation from the officials and men at Darnall.

Mr. H. Steel, chairman of Steel, Peech & Tozer, Limited, has been elected to a seat on the board of the Bengal Iron & Steel Company, Limited. Mr. T. Jowett, a director of the Bengal Iron & Steel Company, Limited, has been elected to the board of Steel, Peech & Tozer, Limited.

Sec.-Lieut. Eric P. Glover, of the 2/1 West Riding Field Company R.E., who has received the Military Cross, is the elder son of Mr. and Mrs. A. W. Glover, of Riversdale, Pool, near Leeds. He gained his engineering experience with the firm of Messrs. M. Glover & Company, engineers, of Leeds, which business was founded by his grandfather. The Cross has also been presented to Sec.-Lieut. (temporary Captain) John Malcolm Fisher, of the 1/5 York and Lancaster Regiment (T.F.), who, prior to the war, was associated with the Owlerton works of Messrs. Brown, Bayley for a period of about five years.

At a recent meeting of the Birmingham Branch of the British Foundrymen's Association reference was made to the death of Mr. G. Hailstone. Mr. H. L. Reason said that in view of the past services rendered to that Branch and the great promise of Mr. Hailstone's career they would all agree that it was a calamity to have lost a man of so much ability. At various times he had placed valuable papers before them, and for some time was Secretary for the Branch. He (Mr. Reason) proposed that the present Secretary be instructed to write a letter of condolence to the widow expressing the sympathy of the Birmingham Branch in her bereavement. The President and Mr. R. Buchanan supported the motion, which was unanimously carried.

The prize of £10 and a silver medal, offered under the Peter Le Neve Foster Trust by the Royal Society of Arts, for an essay on "Zinc, its Production and Industrial Applications," has been awarded to Mr. J. C. Moulden, of Seaton Carew, Co. Durham. Honourable mention has also been awarded to Mr. Ernest Alfred Smith, Deputy Assay Master of the Sheffield Assay Office, for his essay. The adjudicators, on whose recommendation the award was made, reported that the two essays above mentioned were distinctly superior to the others, several of which, nevertheless, were of interest and value. An essay by Mr. Ramji Das Vaishya, of Gwalior, Central India, contained a good deal of information with regard to the production and utilisation of the metal in the East Indies. The prize essay will be read in abstract at one of the meetings of the society after Easter.



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## Some Points worth noting.

Owing to few wearing parts, the Fans are not liable to break down. The mechanical efficiency is high and remains so. The pressure is steady and the volume even and free from pulsations.

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# ELDER'S FOUNDRY COKE

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**The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected and despatched in sheeted wagons.**

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1901.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

# Celtic Collieries, Ltd., Cardiff.

**Telegraph: "OUTPUT, CARDIFF."** **Telephone: 4640 & 4641.**

## New Companies.

**United British Wolfram Company, Limited.**—Capital £1,000 in £1 shares. Registered office: 34, King Street, Cheapside.

**Camden Metal Works, Limited.**—Capital £10,000 in £1 shares. Registered office: 11, Waterloo Place, Regent Street, S.W.

**Nottingham Engineering Company, Limited.**—Capital £2,000 in £1 shares. The first directors are F. B. Johnson, J. King, and G. Fisher.

**Colonial Engineering Agency, Limited.**—Capital £2,000 in £1 shares (300 founders). The first directors are P. Griffith and A. E. Brown.

**Edward Page & Sons, West Bromwich, Limited.**—Capital £30,000 in £1 shares, to carry on the business of ironmasters, &c. Registered office: Roway Iron Works, West Bromwich.

**James, Talbot & Davison (1916), Limited.**—Capital £12,000 in £1 shares (6,000 7 per cent. cumulative preference), to take over the business of engineers carried on by James, Talbot & Davison, Limited, at Horn Hill, Lowestoft.

**Charles Bruce & Company, Limited.**—Capital £15,000 in £1 shares, to carry on the business of ironfounders, mechanical and marine engineers, etc. Secretary (*pro tem.*): J. H. Morton. Registered office: Pinners Hall, Old Broad Street, E.C.

## Applications for Patents.

Chandler, D. Industrial gas burners, and furnaces wherein same can be used. 685. Jan. 15.
Dear, C. Manufacture of steel. 531, 532, 533. Jan. 12.
Forgham, R. G. (*trading* as Townsend, A. P.). Furnaces heated by oil fuel for melting metals. 495. Jan. 12.
Miris Steel Co. Manufacture of steel. 531, 532, 533. Jan. 12.
Steel, Peech & Tozer. Manufacture of metal ingots. 497. Jan. 12.
Townsend, A. P. Furnaces heated by oil fuel for melting metals. 495. Jan. 12.
Ward, J. Furnaces heated by oil fuel for melting metals. 495. Jan. 12.
Homersham, T. H. C. Manufacture of hollow steel or cast-iron ingots or blanks. 977. Jan. 21.
James, J. E. Moulds for casting iron and steel ingots. 888. Jan. 19.
Sowden, W. Separation and extraction of dust and iron from brass borings, &c. 765. Jan 18.
Talbot, B. Moulds for casting iron and steel ingots. 888. Jan. 19.
Dougherty, J. Working blast furnaces. 1285. Jan. 27.
Hall, I. Furnaces, &c. 1072. Jan. 24.
Moorhouse, J. Welding cast steel. 1140. Jan. 25.
Sharp, W. Mould for casting metals, &c. 1238. Jan. 2½.
Bedford, R. A. Manufacture of hollow metal ingots. 1717. Feb. 4.
Craig, R. A. Means for ascertaining hardness of metals, &c. 1473. Jan. 31.
Mather, R., & Moore, H. Means for ascertaining hardness of metals, &c. 1473. Jan. 31.
Armstrong, Whitworth, & Co., Sir W. G. Production of ingots and castings. 1810. Feb. 7.


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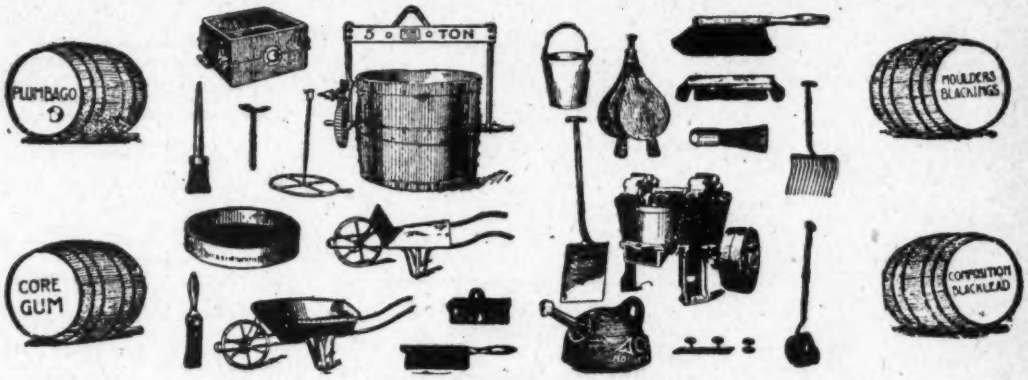
# JAS. DURRANS & SONS,

## Phœnix Works, Penistone, Near Sheffield.

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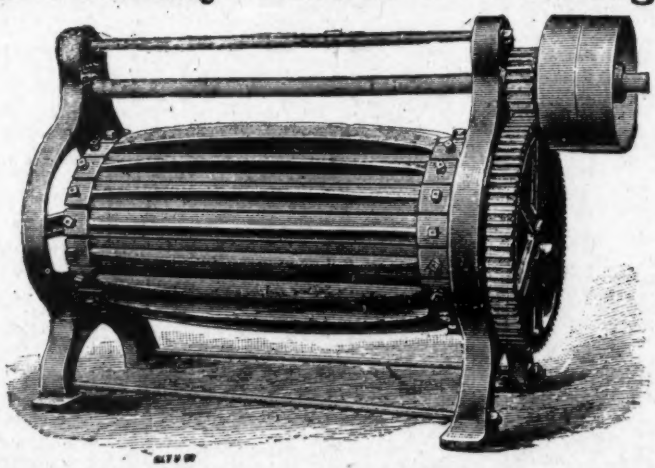
**COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST**

**Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.**

## Improved Foundry Rattler or Fettling Drum.



**These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.**

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

# MONTHLY PRICE LIST.

**The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.**

## Pig-Iron.

### Cleveland.

| | s. | d. |
|---|---|---|
| Cleveland No. 1 .. .. .. | 96 | 6 |
| ,, No 3 .. .. .. | 92 | 6 |
| ,, No. 4 foundry .. .. | 91 | 6 |
| ,, No 4 forge .. .. | 89 | 6 |
| ,, Mottled .. .. .. | — | |
| ,, White .. .. .. | — | |
| East Coast hematite, mixed Nos. .. | 140 | 0 |
| Cleveland warrants .. ..Buyers | 91 | 6 |

Above prices are for early f.o.b. deliveries and as regards Cleveland iron are for G.M.B. brands. The warrant quotations are the sellers' cash prices.

### Scotland.

| | s. | d. |
|---|---|---|
| Standard Foundry (Glasgow Market settlement price) .. .. .. | 91 | 1½ |
| Warrants, ditto .. .. .. | 97 | 6 |

Makers' prices :—

| | s. | d. | | s. | d. |
|---|---|---|---|---|---|
| Gartsherrie No. 1 | 130 | 0 | No. 3 | 122 | 6 |
| Coltness No. 1 | 142 | 6 | No. 3 | 122 | 0 |
| Summerlee No. 1 | 125 | 0 | No. 3 | 120 | 0 |
| Langloan No. 1 | 130 | 0 | No. 3 | 125 | 0 |
| Calder No. 1 | 125 | 0 | No. 3 | 120 | 0 |
| Clyde No. 1 | 125 | 0 | No. 3 | 120 | 0 |
| Carnbroe No. 1 | 120 | 0 | No. 3 | 115 | 0 |
| Monkland No. 1 | 117 | 6 | No. 3 | 116 | 6 |
| Shotts No. 1 | 130 | 0 | No. 3 | 122 | 6 |
| Govan No. 1 | 116 | 0 | No. 3 | 115 | 0 |

(All deliverable alongside Glasgow.)

| | | | | | |
|---|---|---|---|---|---|
| Glengarnock | No. 1 | 125 | 0 | No. 3 | 120 | 0 |

(Deliverable alongside Ardrossan.)

| | | | | | |
|---|---|---|---|---|---|
| Dalmellington | No. 1 | 122 | 0 | No. 3 | 120 | 0 |
| Eglington | No. 1 | 122 | 6 | No. 3 | 120 | 0 |

(Deliverable alongside Ayr.)

| | | | | | |
|---|---|---|---|---|---|
| Carron | No. 1 | — | | No. 3 | — | |

(F.a.s. Grangemouth.)

| | s. | d. |
|---|---|---|
| Scotch hematite, f.o.t. steelworks | 137 | 6 |

### Lancashire.

| | s. | d. | s. | d. |
|---|---|---|---|---|
| Lancashire No. 3 foundry f.o.t. | — | | — | |
| Lincolnshire No. 3 foundry .. | — | | 93 | 3 |
| Derbyshire No. 3 foundry .. | 92 | 3 | 92 | 6 |
| Staffordshire No. 3 foundry | 92 | 6 | — | |
| Cleveland No. 3 foundry | — | | 95 | 8 |

(All delivered equal Manchester.)

| | | | | |
|---|---|---|---|---|
| Scotch No. 3 | Gartsherrie .. | — | — | |
| | Glengarnock .. | — | 130 | 0 |
| | Eglington .. | — | — | |
| | Summerlee .. | — | 127 | 0 |

(Delivered Manchester Docks.)

### North-West of England.

| | s. | d. | s. | d. |
|---|---|---|---|---|
| Bessemer mixed numbers net f.o.b. .. .. .. | — | | Nominal | |
| Hematite warrants net cash .. | — | | 115 | 0 |
| Lorn cold-blast charcoal iron | — | | — | |

### The Midlands.

| | | s. | d. | s. | d. |
|---|---|---|---|---|---|
| Staffs. | Part Mine forge .. | 90 | 0 | 91 | 0 |
| | Best All Mine .. | — | | 160 | 0 |
| | Cold Blast .. .. | — | | 180 | 0 |

Strong forge, about 1s. less than grey forge; Mottled and White, about 2s. less than forge; Foundry No. 3, 3s. to 5s. above forge; No. 1 and No. 2, from 1s. 6d. to 2s. above No. 3; No. 1, about 2s. above No. 2.

| | | | | |
|---|---|---|---|---|
| Northampton foundry .. | 86 | 0 | 88 | 0 |
| North Staffs. foundry .. | — | | — | |
| Derby foundry .. .. | 90 | 0 | 91 | 0 |
| Nottinghamshire foundry .. | — | | — | |
| Leicestershire foundry .. | — | | 93 | 0 |
| Shropshire Cold-Blast .. | — | | 180 | 0 |

(Delivered South Staffordshire Works, net cash monthly.)

### Lincolnshire.

| | s. | d. | s. | d. |
|---|---|---|---|---|
| Forge .. .. .. .. | — | | 90 | 3 |
| Grey forge .. .. .. | — | | 90 | 3 |
| Basic .. .. .. .. | — | | — | |
| No. 3 foundry .. .. | — | | 92 | 0 |
| No. 4 foundry .. .. | — | | — | |

F.o.t. Makers' Works.

### South Wales.

| | s. | d. | s. | d. |
|---|---|---|---|---|
| Welsh Hematite .. .. | 150 | 0 | Nom. | |

## Ferro-Alloys.

Net, Delivered Sheffield steel works.

| | £ | s. | d. |
|---|---|---|---|
| Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit. Per ton | 35 | 0 | 0 |
| Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton | 29 | 10 | 0 |
| Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit. Per ton | 28 | 0 | 0 |
| Ferro-chrome : Specially refined, guaranteed maximum 2% carbon, broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton | 86 | 0 | 0 |
| Ferro-vanadium : 33/40% Va., perlb. of Va. contained in the alloy .. | 0 | 14 | 0 |
| Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton | 27 | 10 | 0 |
| Ferro-titanium : 23/25%, per pound carbonless .. .. .. .. | 0 | 1 | 9 |
| Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained .. | 0 | 18 | 0 |
| Ferro-phosphorus : 20/25%. Per ton | 16 | 10 | 0 |
| *Ferro-manganese 80% .. .. | 25 | 0 | 0 |
| ,, export .. .. | — | | |

* F.o.b. Liverpool.

## Iron Castings.

### Cleveland.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Columns (plain) .. | — | | | to | — | |
| Pipes, 1¼ to 2½ in. .. | — | | | | — | |
| ,, 3 to 4 in. .. | — | | | | — | |
| ,, 5 to 8 in. .. | — | | | | — | |
| ,, 10 to 16 in. .. | — | | | | — | |
| ,, 18 to 24 in. .. | — | | | | — | |
| Chairs .. .. .. | — | | | | — | |
| Floor plates (open sand) | — | | | | — | |

(At work.)

## Non-Ferrous Metals.

### Copper.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Standard, Cash .. | 115 | 10 | 0 | 116 | 0 | 0 |
| Three months .. | 113 | 0 | 0 | Nominal | | |
| Electrolytic .. | 135 | 0 | 0 | 137 | 0 | 0 |
| Tough .. .. | 127 | 0 | 0 | 129 | 0 | 0 |
| Best selected .. | 128 | 0 | 0 | 130 | 0 | 0 |

### Tin.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Standard, Cash .. | 199 | 0 | 0 | 199 | 10 | 0 |
| ,, Three months | 193 | 5 | 0 | 193 | 10 | 0 |
| English Ingots .. | 202 | 0 | 0 | 203 | 0 | 0 |
| Bars .. .. | 203 | 0 | 0 | 204 | 0 | 0 |
| Refined .. .. | — | | | 207 | 0 | 0 |

### Spelter.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| American .. .. | — | | | 100 | 0 | 0 |
| Specials .. .. | — | | | — | | |
| Hard .. .. | 70 | 0 | 0 | 75 | 0 | 0 |
| British .. .. | 103 | 0 | 0 | 105 | 0 | 0 |

### Lead.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Soft Foreign .. .. | — | | | 35 | 0 | 0 |
| English .. .. .. | — | | | 35 | 17 | 6 |

### Antimony.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Regulus .. .. .. | — | | | 95 | 0 | 0 |

### Aluminium.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Virgin Metal 98/99% per ton | 155 | 0 | 0 | 200 | 0 | 0 |

### *Chromium (Metallic).

| | | | | | | |
|---|---|---|---|---|---|---|
| 98/99% purity, per lb. | — | | | — | | |

### *Nickel.

| | | | | | | |
|---|---|---|---|---|---|---|
| In cubes, 98/99% purity Per ton | 220 | 0 | 0 | | | |

### *Tungsten Metal Powder.

| | | | | | | |
|---|---|---|---|---|---|---|
| 96/98% purity .. per lb. .. | 0 | 5 | 10 | | | |

### *Molybdenum Metal.

| | | | | | | |
|---|---|---|---|---|---|---|
| 96/98% purity .. per lb. .. | — | | | | | |

### *Cobalt Metal.

| | | | | | | |
|---|---|---|---|---|---|---|
| 97% purity .. per lb. .. | 0 | 8 | 0 | | | |

### Quicksilver.

| | | | | | | |
|---|---|---|---|---|---|---|
| 75 lb. bottle .. .. .. | 16 | 13 | 9 | | | |

* Net, Delivered Sheffield Works.

## Scrap Iron and Steel.

### Cleveland.

| | s. | d. | s. | d. |
|---|---|---|---|---|
| Steel scrap, heavy melting .. | 97 | 6 | to 100 | 0 |
| Iron scrap cast (cupola metal) | 75 | 0 | 77 | 6 |

### London (f.o.b.).

| | | | | |
|---|---|---|---|---|
| Heavy steel .. .. | 90 | 0 | | |
| Light ,, .. .. .. .. | 50 | 0 | | |
| Heavy cast .. .. .. .. | 80 | 0 | | |

## Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations :—

| | A. Joseph. £ | s. | d. |
|---|---|---|---|
| Hy. Electrolytic Copper Scrap .. | 115 | 0 | 0 |
| Hy. Selected Scrap Brass .. | 76 | 0 | 0 |
| Hy. Tinned Copper Wire .. | 105 | 0 | 0 |
| Best Selected Gunmetal Scrap .. | 96 | 0 | 0 |

Re-melted Ingot Lead 30s. under English Lead price on date of order.

## Stocks.

### Pig-Iron in Public Store.

| | Mar. 30. Tons. | Inc. + or Dec. – since 1 pr. 1, 1915. Tons. |
|---|---|---|
| Connal's at Glasgow Scotch .. .. | 1,000 | No change. |
| Ditto other makes .. | — | No change. |
| Connal's at Middlesbrough .. .. | 59,123 | – 69,743 |
| Connal's at Middlesbrough hematite .. | — | No change. |
| West Coast hematite | 1,381 | – 1,479 |

### Metals.

| | | |
|---|---|---|
| Copper, Europe and afloat .. .. | — | — |
| Tin, London, Holland, U.S.A. and afloat | — | — |

## Coke.

### Middlesbrough.

| | s. | d. | s. | d. |
|---|---|---|---|---|
| Gas Coke .. .. .. | — | | 29 | 0 |
| Foundry Coke .. .. | 45 | 0 | 50 | 0 |
| Furnace Coke .. .. | — | | 30 | 6 |

### Newcastle-on-Tyne.

| FOUNDRY COKE— | F.o.b. s. | d. | Dunston s. | d. |
|---|---|---|---|---|
| Original Garesfield .. | — | | 45 | 0 |
| Mickley .. .. .. | — | | 45 | 0 |
| Stella Garesfield .. .. | — | | 45 | 0 |
| Priestman's Garesfield .. | — | | 45 | 0 |
| Consett Garesfield .. | — | | 45 | 0 |
| Newcastle gas coke .. | — | | 27 | 0 |

### Cardiff.

| | s. | d. | | s. | d. |
|---|---|---|---|---|---|
| Special Foundry Coke .. | 60 | 0 | to | 65 | 0 |
| Foundry Coke .. .. | 52 | 6 | to | 57 | 6 |
| Furnace Coke .. .. | 45 | 0 | to | 50 | 0 |

### Leeds.

| | | | | |
|---|---|---|---|---|
| Furnace Coke (washed) .. | — | | 24 | 0 |

### Birmingham.

| | | | | |
|---|---|---|---|---|
| Foundry Coke .. .. | — | | — | |
| Furnace Coke .. .. | — | | — | |
| Gas Coke .. .. .. | 28 | 0 | 28 | 0 |

### Glasgow.

| | | | | |
|---|---|---|---|---|
| Foundry Coke .. .. | 35 | 0 | 36 | 0 |
| Furnace Coke .. .. | 26 | 0 | 27 | 0 |
| Gas Coke .. .. .. | — | | — | |

### London.

| | | |
|---|---|---|
| Welsh or Durham Foundry, d/d London Stations, in truck .. .. .. | — | — |
| Ditto, d/d Birmingham Stations .. .. .. | — | — |
| Yorkshire, d/d London Stations, in truck .. | — | — |
| Ditto, d/d Birmingham Stations .. .. .. | — | — |

## SITUATIONS VACANT AND WANTED.

FOUNDRY FOREMAN, disengaged, used to all classes of work, light and heavy; green sand, dry sand; fair knowledge of loam; experience in non-ferrous metals; age 42.—Write, Box 602, Offices of *Foundry Trade Journal*, 165, Strand, W.C.

WANTED, a thoroughly experienced and qualified MAN to take charge of the working of gas producers at a large Steelworks. Must also have complete knowledge of gas analysis, and be well used to handling workmen. Reply stating age, qualifications, and remuneration required to Box 820, Offices of *Foundry Trade Journal*, 165, Strand, London.

## FOR SALE AND WANTED.

LYCOPODIUM 500 kilogrammes (1,100 lbs.) offered FOR SALE by Swedish exporters. Reply in the first instance to A.M.H. (B/580/16), c/o Swedish Chamber of Commerce, 5, Lloyd's Avenue, London, E.C.

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COMPLETE TROPENAS STEEL PRODUCING PLANT, consisting of Cupola capable of melting 10 tons per hour, with Waygood Electric Hoist, Staging, and steam-driven Roots Blower; 2 2-ton Converters with electric tilting gear, and very fine Steam Twin Cylinder Air-blowing Engine; Lancashire Boiler, by Galloway, Limited, Manchester, 30 ft. by 8 ft., 160 lbs. working pressure, with Gauges, Pipes and Mountings; also 4 3-ton and 2 9-ton Lip Pouring Ladles. The plant is now in operation, and is offered for delivery in, approximately, six months. It is capable of producing 25 tons of steel per 10-hour day, and is suitable for making castings up to 10 tons in weight.—For further particulars, apply to No. 596, Offices of *Foundry Trade Journal*, 165, Strand, W.C.


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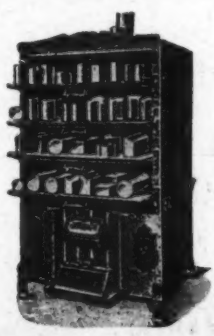

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Gentlemen,

We are very pleased with the Core Oven we recently purchased from you. We find it dries the cores quickly without burning them. It is very handy and economical to use and is altogether superior to other ovens of this type we have in use.

Will you please quote us your best price for four more like it,

Yours faithfully,
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(Sign'd) W. B. LAKE, Director.

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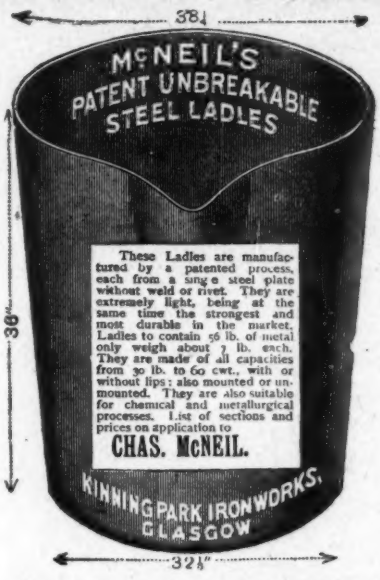
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30"
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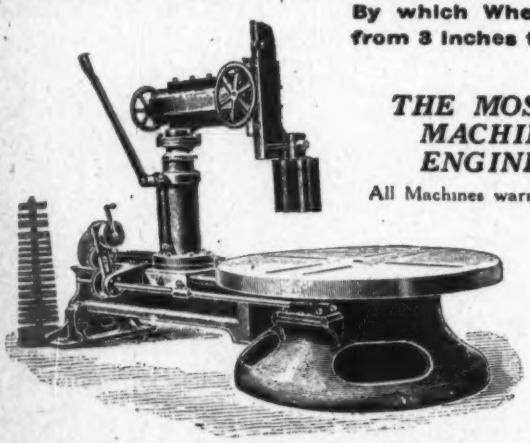

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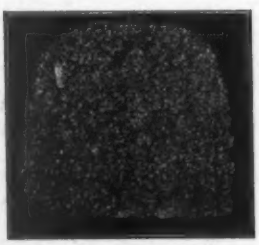
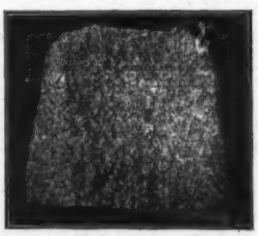
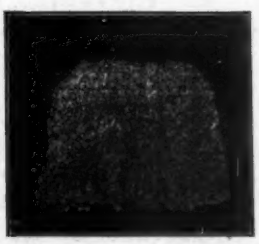

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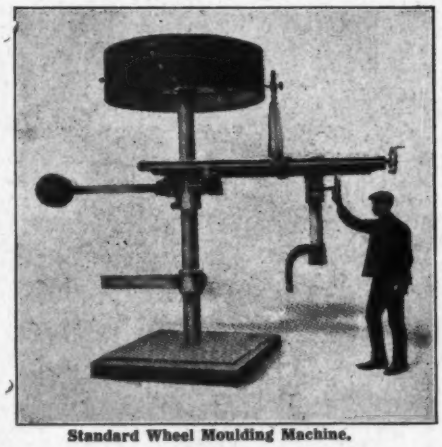

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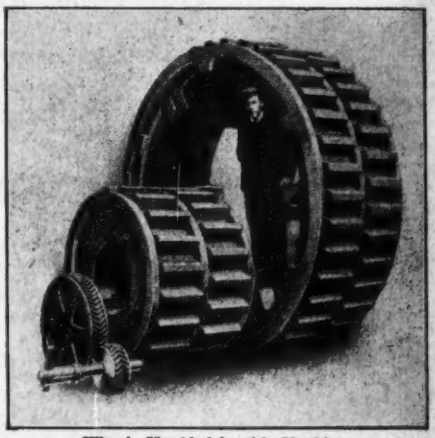

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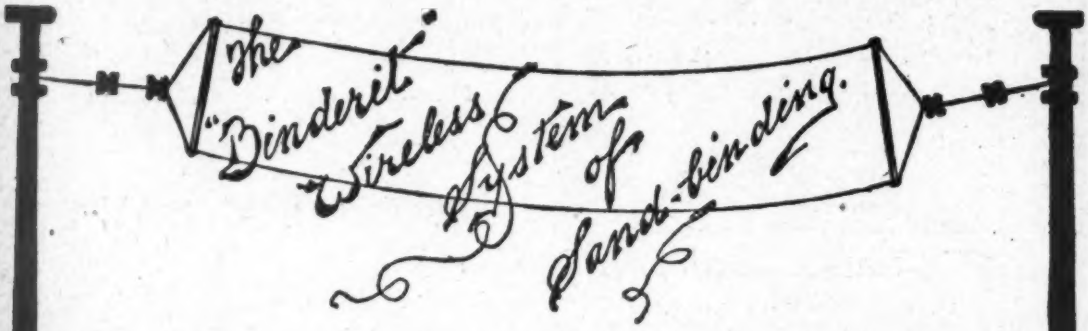


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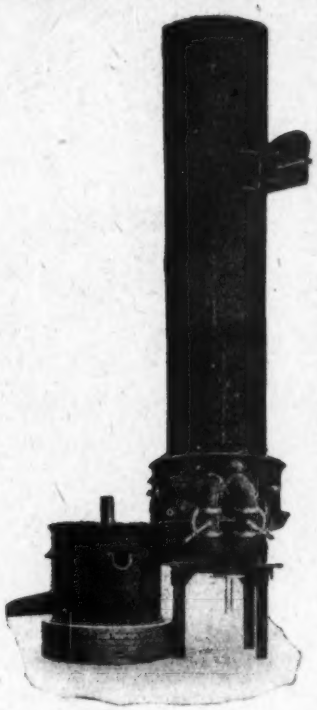

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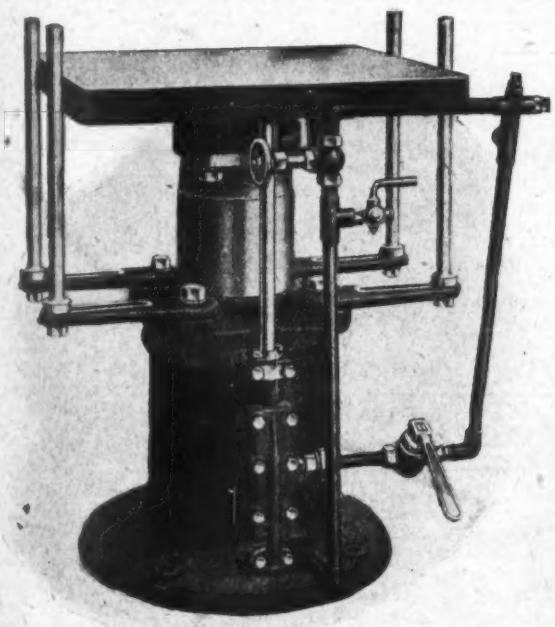

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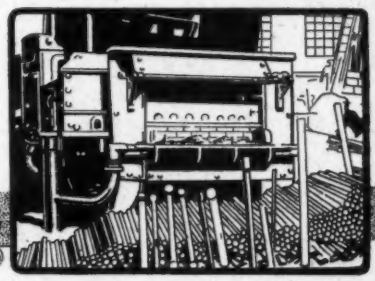

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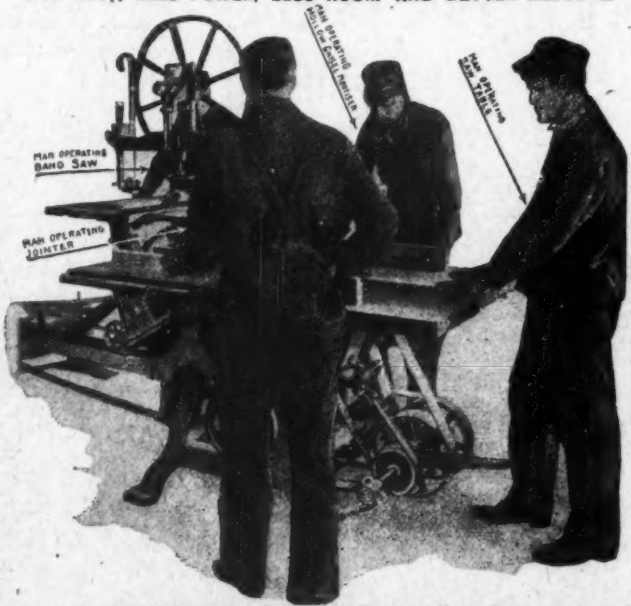


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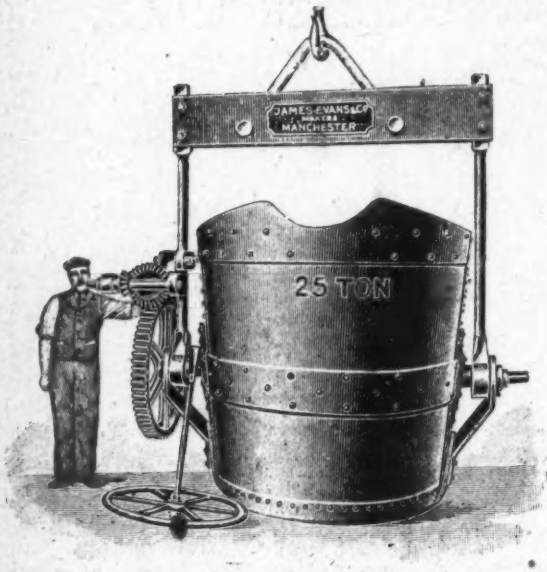


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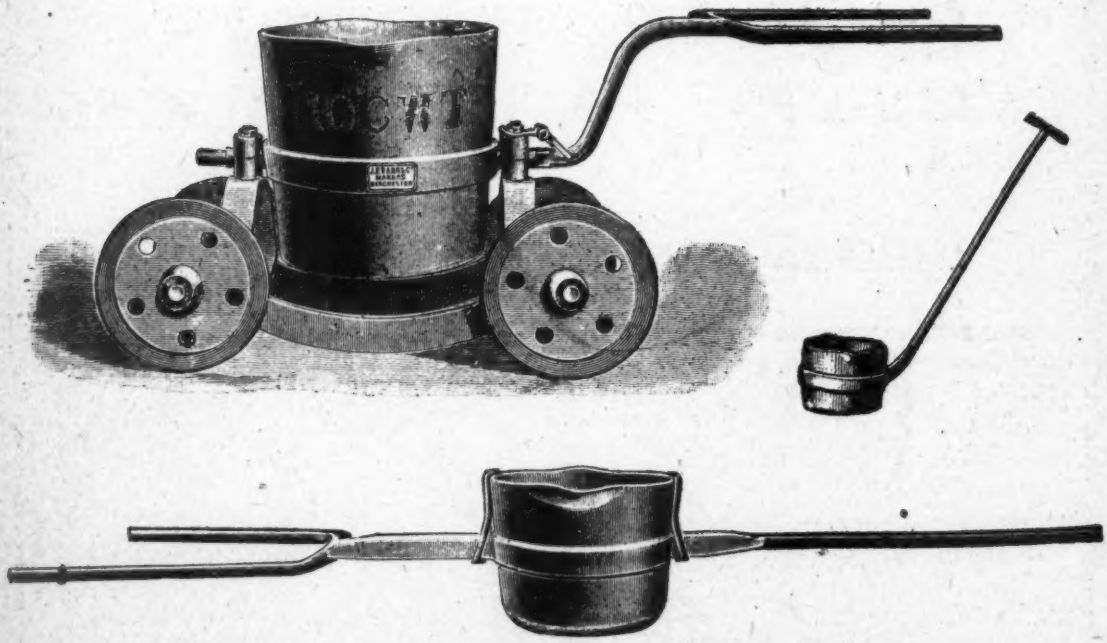

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